



# NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

**Advanced Sea Base Enabler (ASE)  
Capstone Design Project**

by

MSSE Cohort 311-081 – Group #1

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<b>13. ABSTRACT (maximum 200 words)</b> As part of a Naval Postgraduate School's capstone project in Systems Engineering, a project team from cohort 311-081 performed a Systems Engineering analysis of an Advanced Sea Base Enabler (ASE). For a sea base to be truly beneficial a capability must exist that supports efficiently transporting needed materiel from the sea base to the desired debarkation point. The capability must support peace-time, non-combat operations' and war-time, combat operations' logistics and support needs. The solution must be cost effective and capable of operating under all environmental conditions, including sea states, under which necessary military operations are expected to take place and must support a transport rate sufficient to ensure materiel is delivered within operational time requirements. The proposed ASE is intended to fully enable the potential of the sea base. The bulk of effort by the team was on collection, analysis and validation of operational requirements, functional analysis based on the operational requirements, consideration of possible alternatives compared to the collected requirements, prioritizing the alternatives based on stakeholder priorities and selection and documentation of a preferred alternative. Additionally, the team conducted cost analysis and risk analysis, as well as a limited simulation study.			
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## **EXECUTIVE SUMMARY**

As part of a Naval Postgraduate School's capstone project in Systems Engineering, a project team from cohort 311-081 performed a Systems Engineering analysis of an Advanced Sea Base Enabler (ASE). The focus of the effort was on a systems engineering analysis for the Concept Development stage of acquisition. The team performed a simplified ASE AoA that culminated in recommended alternatives for specific mission types.

The functional requirements needed to support an ASE capability for several specific operational scenarios were considered. The initial operational scenarios were Major Combat Operation, Police Enforcement Operation, Natural Disaster Relief, and Humanitarian Aid. The scenarios were down selected to two missions, Major Combat Operation and the Humanitarian Aid, for the final decision analysis as these two missions bracketed the other two and covered the major mission features being analyzed.

An iterative Systems Engineering process of Formulation, Analysis and Interpretation was utilized. Existing or planned alternative systems were researched and the focus of effort was on collection, analysis and validation of operational requirements, functional analysis based on the operational requirements, consideration of possible alternatives compared to the collected requirements, prioritizing the alternatives based on stakeholder priorities and selection and documentation of a preferred alternative. Many stakeholders were identified and requirements information collected from them through a series of meetings, phone calls and email exchanges. Based on the requirements a functional decomposition and a value hierarchy were developed and used in development of evaluation criteria for the ASE alternatives. Three top level functions that an ASE must be capable of performing were identified: Deploy ASE, Process Cargo and Transport Cargo. These functions cover the essential ASE requirements to be able to get to the sea base, support transfer of cargo between the ASE and the sea base or final destination and move the cargo to its destination.

System alternatives were researched and seven possibilities settled on for further analysis and evaluation. These alternative platforms include current systems, craft that

are currently under development and conceptual systems that are not in the acquisition cycle. The seven alternatives were

- Landing Craft Air Cushion (LCAC)
- Ship to Shore Connector (SSC)
- Transformable Craft (T-Craft)
- Logistics Support Vessel (LSV)
- Landing Craft, Utility (LCU)
- Joint High Speed Vessel (JHSV)
- Airlift

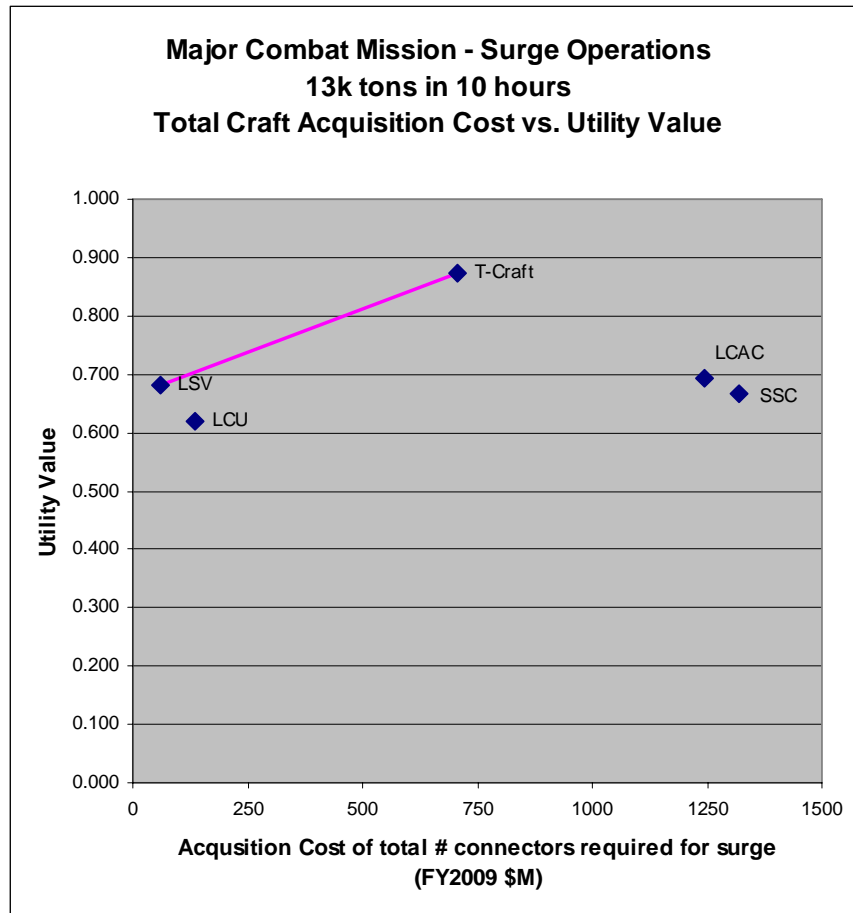
Detailed modeling and simulation of a baseline case utilizing LCACs was performed although the M&S was not ultimately utilized in the trade-off analysis. The model was built using a common M&S tool (Extend) for ease of use by future research teams. The majority of the decision analysis utilized a simplified Multi-Attribute Utility Theory (MAUT) and was executed utilizing spreadsheets. From the extensive list of requirements parameters, the team selected a set of six parameters for decision analysis based on stakeholder inputs and the team's requirements analysis. The six critical decision analysis parameters were:

Table 1: Decision Analysis Parameters

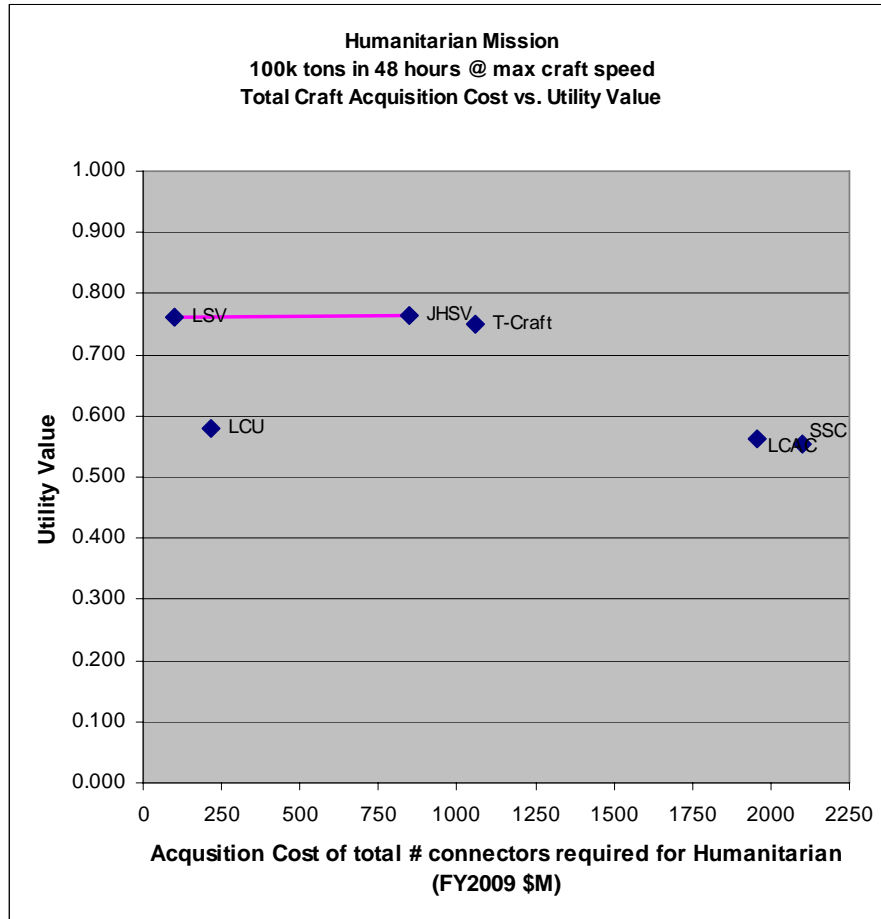
Parameter	Threshold	Objective
Self-Deployment Range	1000 nautical miles	2500 nautical miles
Crew size	100	0
Intra-Theater Range	25 nautical miles	250 nautical miles
Speed	20 knots	40 knots
Cargo Capacity	300 short tons	600 short tons
Beachability	No	Yes

Value curves and weights for these parameters were developed based on an understanding of stakeholder priorities. Due to project constraints, values and weights were only developed for two of the four initial missions considered, specifically Major Combat Operation and Humanitarian Aid. These two missions were selected as being the most and least stringent respectively, and represented the spectrum of key attributes of the four initial missions. Utilizing the MAUT approach the team developed overall utility values for each alternative for the two selected missions. The T-Craft appears to be the best by value for the Major Combat Operation and the JHSV was the best for the Humanitarian Aid mission.

The team also conducted life-cycle cost analysis of each alternative. Cost estimates were based on actual data available for current systems, while for conceptual systems costs were input based on parametric analysis and comparison to similar systems. The team conducted a cost-benefit analysis for the two missions using notional data based on the number of vessels required to support moving a specified amount of cargo in a specified time, as shown in Figures 1 and 2.



**Figure 1: Cost Benefit Analysis Major Combat Mission**



**Figure 2: Cost Benefit Analysis Humanitarian Aid Mission**

Figures 1 and 2 show the cost versus utility results for the notional combat and humanitarian missions, respectively. The lines show the Pareto Frontier composed of the non-dominated solutions. For the Major Combat Operation Mission, the cost-benefit analysis reveals that for the non-dominated systems the T-Craft offers the highest utility but with a moderate cost as compared across the alternatives. For the Humanitarian Mission, the LSV and JHSV are the non-dominated solutions with T-Craft a close third. All have low to moderate cost and good utility. T-Craft would be eliminated from consideration based on the cost-benefit plot with a lower utility but higher cost than LSV and JHSV. Obviously, a final decision on the best alternative depends on many factors and is difficult to capture completely when rolled into single scores. Based on the cost-

benefit analysis for the specified Humanitarian Aid mission parameters the best choice of the non-dominated solutions appears to be the LSV.

Recommendations are made regarding the best ASE alternatives for each of the missions considered, recognizing the assumptions and limitations of the study. Based on the analysis, the T-Craft seems to be the best alternative for operations and quick response actions that require feet dry beach deployment of personnel and equipment. For operations that allow for an austere port and do not require landing of personnel or equipment directly on a beach the JHSV may be the best alternative of those considered when its additional capabilities are considered.

In addition to recommendations regarding the best ASE alternatives, recommendations for future studies and work related to ASEs were made. These include more detailed simulation study that examined the full range of alternatives in an appropriate operational setting, as well as a thorough cost analysis. Additionally, a study that examines a potential fleet architecture, which looks at a combination of sea base enabler platforms in order to close current gaps in for both Army and USMC cargo transfer, would be of great benefit.

## ACRONYMS

Acronym	Definition
ACAT	Acquisition Category
ACV	Air Cushion Vehicle
AJACS	Advanced Joint Air Combat System
ANOVA	Analysis of Variance
AOA	Analysis of Alternatives
ASE	Advanced Sea Base Enabler
AT/FP	Anti-Terrorism / Force Protection
AWMP	Army Watercraft Master Plan
AWS	Army Watercraft Systems
BAA	Broad Agency Announcement
C2	Command and Control
C4I	Command, Control, Communications, Computers, Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAIV	Cost As an Independent Variable
CONOPS	Concepts of Operation
CONUS	Continental United States
CSG	Carrier Strike Group
DOD	Department of Defense
DON	Department of the Navy
DOTMLPF	Doctrine, Organization, Training, Materiel, Logistics, Personnel, and Facilities
EMW	Expeditionary Maneuver Warfare
ESG	Expeditionary Strike Group
FCS	Future Combat System
HEMTT	Heavy Expanded Mobility Tactical Truck
ICDR	Initial Critical Design Review
IED	Improvised Explosive Device
INLS	Improved Navy Lighterage System
INP	Innovative Naval Prototype
IOC	Initial Operational Capability

<b>Acronym</b>	<b>Definition</b>
ISB	Intermediate Staging (and Support) Base
JFCOM	Joint Forces Command
JFEO	Joint Forcible Entry Operations
JFTL	Joint Future Theater Lift
JHL	Joint Heavy Lift
JHSV	Joint High Speed Vessel
JIC	Joint Integrating Concept
JMIC	Joint Modular Intermodal Containers
JOC	Joint Operating Concepts
LCAC	Landing Craft Air Cushion
LCU	Landing Craft Utility
LMSR	Large, Medium-speed, Moll-on/roll-off ship
LOTS	Logistics Over-the-Shore
LSV	Logistics Support Vessel
M&S	Modeling and Simulation
MARAD	Maritime Administration
MAUT	Multi-Attribute Utility Theory
MCO	Major Combat Operation
MEB	Marine Expeditionary Brigade
MLP	Mobile Landing Platform
MOE	Measures of Effectiveness
MOOTW	Military Operations Other Than War
MOP	Measures of Performance
MPFF	Maritime Pre-positioning Force (Future)
MPG	Maritime Pre-positioning Group
NATO	North Atlantic Treaty Organization
OMFTS	Operational Maneuver from the Sea
ONR	Office of Naval Research
OSHA	Operational Safety and Health Administration
POR	Program of Record
RAM	Reliability, Availability and Maintainability
R&D	Research & Development
ROMO	Range of Military Operations
RSL	Ready Storage Locker
SES	Surface Effect Ship

<b>Acronym</b>	<b>Definition</b>
SLEP	Service Life Extension Program
SOCOM	Special Operations Command
SSC	Ship to Shore Connector
STOL	Short Take-Off and Landing
STOM	Ship-to-Objective Maneuver
TOC	Total Ownership Costs
TRANSCOM	United States Transportation Command
USEUCOM	United States European Command
VTOL	Vertical Take-Off and Landing
WMD	Weapons of Mass Destruction

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# **I. INTRODUCTION**

## **A. PROJECT OVERVIEW**

Seabasing is a term that refers to a collection of ships at sea conducting operations that enable forces to operate in theater without a large logistical footprint ashore. Such an operation may require a wide variety of vessels to transfer various types of cargo such as pallets, containers, liquids (i.e. fuel, water) and vehicles between ships and from the sea base platforms to the final cargo destination. (NRC, 2005)

The fundamental seabasing scenario positions a collection of ships at sea to act as a base of operations for operational forces in theater. These ships would require periodic re-supply of cargo, both for their own consumption and for re-supplying deployed forces. This cargo could be delivered by a variety of ships (including fast combat support ships, commercial containerhips, and other pre-positioning ships), or aircraft. These ships could either join the sea base or serve as a cargo platform serving the vessels that deliver the cargo to the final destination, or they could deliver their cargo to one or more sea base ships for storage and/or redistribution. An ASE, then, is a system that is used to enable the sea base by transporting materials to and from the sea base.

The ASE team's efforts focused on understanding the capabilities, operational activities, requirements, and functions that enable the sea base concept to be fully realized, specifically on the need to transport cargo from the sea base to its final destination. Once these needs were understood the team examined potential alternatives that might meet the requirements and evaluated them to identify the best candidates. The team utilized an iterative Systems Engineering approach culminating in a limited Analyses of Alternatives (AOA) comparing the potential ASE candidates that were identified. The team faced many challenges, among the most significant being the challenge of determining appropriate need for this problem and scoping the project into something meaningful that could be accomplished within the bounds of time available.

## **B. PURPOSE**

The purpose of this project is to examine the issue of assembling and transporting cargo from a sea base to the desired destination and make recommendations regarding the best approaches for meeting those objectives. The key research questions that motivated the ASE team's efforts are:

- What requirements and functions are required of an ASE to meet the operational capabilities of the sea base and the operational forces it serves?
- What ASE concept is best at performing the required functions?
- What are the risks and limitations of the ASE concepts?

These questions are addressed by the analyses discussed in this report. The team's goal was to generate an analysis that was useful to the joint DOD community.

## **C. METHODOLOGY / APPROACH**

The ASE team primarily used the systems engineering methodology as described by Sage and Armstrong (2000), with modifications or additions as deemed appropriate by the team. The basic steps and processes that were utilized during the execution of the project are discussed below.

Sage and Armstrong outline three major steps in the system engineering process, as shown in Figure 1.

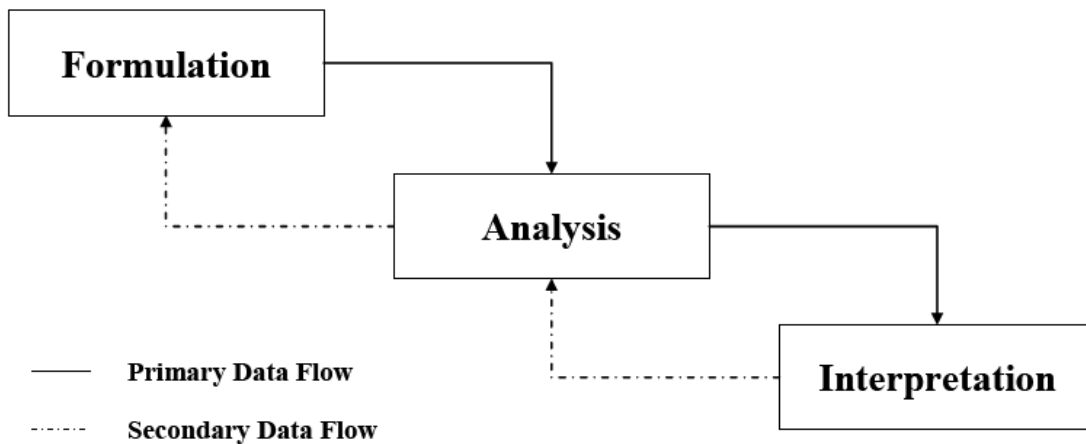


Figure 1. Systems Engineering Process  
Images from: (Sage and Armstrong, 2000)

The following sections of the report discuss the different steps in the system engineering process and how the team applied them. Detailed results from each of the stages are reported on in later sections. As with most systems engineering processes, the Sage and Armstrong approach is iterative and the team revisited many of the steps repeatedly during the project.

## **1. Formulation**

The Formulation step in the systems engineering process is used to clearly identify the problem, evaluate the objectives and/or goals of the solution and hypothesize potential alternatives and the metrics that could be used. The major components of Formulation that the ASE team utilized are described below.

### **a. Problem Definition**

During this step the team identified and described the problem being considered. An initial problem statement and revised problem statement were developed based on the team's research and analysis. Stakeholders were identified and the team researched the stakeholder's interpretation of the problem, identified requirements and captured the relevant constraints that impact the problem. To better understand the problem and potential solutions, the team members reviewed relevant documentation. During this phase of the project mission analysis and operational scenarios were also identified.

### **b. Value System Design**

The team developed a value system based upon the needs and objectives identified by the stakeholders. A value or objective hierarchy was developed that provided the basis for decision criteria for identifying and selecting the “best” system based upon the objectives and related measures. The value system is a hierarchy of functional elements, with potential measures of effectiveness, which relate back to the requirements identified and represent the functional approach for satisfying those requirements.

## **2. Analysis**

This step in the systems engineering process is used to evaluate the potential concepts, alternatives, and solutions and examine how they meet the requirements identified by earlier steps. The following briefly describes the elements of the analysis stage of systems engineering and how the team applied them.

### **a. Systems Analysis and Modeling**

This is the stage of systems engineering where modeling and simulation (M&S) and other analytical processes are utilized to assess the effectiveness of the alternatives. Due to limitations in scope the team performed limited systems analysis and modeling. The tools and processes used help determine specific impacts or consequences of the various alternatives being considered based on the metrics identified in the value system. The team did perform some detailed M&S development to establish a baseline performance assessment but did not have time for extensive M&S of the potential alternatives. For the most part the team assumed the stated functional performance specifications of the alternatives were accurate. The team performed limited spreadsheet analysis to examine how effective the potential alternatives were at executing certain mission elements.

### **b. Refinement of the Alternatives**

As a better understanding of the system functions becomes clear based on analysis of the alternatives and their ability to meet the identified requirements, it is typical to adjust and optimize system characteristics, within allowable parameters, to better meet the identified needs. The team did very little in this respect due to time limitations.

## **3. Interpretation**

This step utilizes information generated from each of the previous steps to assist in the decision making process. For example, by comparing the value system with the system analysis results the team can make assessments as to what alternatives better meet specified needs.

**a. Decision making**

By evaluating the alternatives against selected parameters from the value system, the team was able to assess the performance of the various alternatives against requirements. The team used Multi-Attribute Utility Theory (MAUT) to assess alternatives against requirements and performed a limited cost analysis and cost-benefit analysis to support decision making. Attributes and appropriate weights were selected based on an understanding of stakeholder priorities. A decision matrix was developed to compare the alternatives based on the selected parameters.

**b Planning for Action**

The team recommends preferred alternatives and provides justification and discussion of the recommendations. Additional insights into the problem are discussed along with suggestions for follow on research.

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## **II. OPERATIONAL BACKGROUND**

### **A. SEABASING OVERVIEW**

#### **1. Seabasing: Introduction**

A cornerstone of America's continued military supremacy is our ability to project combat power rapidly and virtually without hindrance to widespread areas of the world. Our power projection capability depends on sustained access to regions of political and operational concern (NDP, 1997). Any number of circumstances might compromise our operational forward presence and therefore weaken our ability to apply military power, which could reduce our military and political influence in key regions of the world. These circumstances have led the United States Department of Defense (DOD) to strategize on the need to develop an off shore military presence known as seabasing (U.S. Navy, 2007).

The concepts of seabasing have recently received more attention from the DOD community as access to foreign land bases has become an increasingly serious political and physical issue. As stated previously, the sea base is a fundamental concept of this project. The Navy's "Sea Power 21" vision includes the idea of a sea base as one of several pillars supporting Naval Sea Power for the future (Clark, 2002). The Sea Power 21 document describes the benefits of seabasing as:

- Pre-positioned war-fighting capabilities for immediate employment.
- Enhanced joint support from a fully netted, dispersed naval force.
- Strengthened international coalition building.
- Increased joint force security and operational agility.
- Minimized operational reliance on shore infrastructure.

The key capabilities required to support seabasing are identified as:

- Enhanced Afloat Positioning of Joint Assets.
- Offensive and Defensive Power Projection.

- Command and Control (C2).
- Integrated Joint Logistics.
- Accelerated deployment and employment timelines.

The “Cooperative Strategy for the 21st Century Sea power” of the joint forces of the USMC, Coast Guard and US Navy (U.S. Navy, 2007) also indicates the importance of logistics and supply to meeting our nation’s naval objectives and supporting national strategic objectives. While seabasing is clearly perceived as a key capability of the National and Naval Strategies, the problem still exists of how to enable the sea base.

Making a sea base actually work requires surmounting numerous challenges. In their August 2003 report, the Defense Science Board Task Force on Seabasing confirmed the need for seabasing and identified twelve issues they felt needed to be addressed to fully realize the capability of the sea base. (Defense Science Board, 2003) The six issues related to “new capabilities” requiring development were:

1. Cargo transfer at sea.
2. A long range heavy lift aircraft that can be based at sea with capability to support forces ashore and transport troops.
3. Ships of appropriate design.
4. A shared data communication system with sufficient bandwidth, redundancy, and robustness.
5. A logistics support system that handles all Service material interchangeably.
6. Intra-theater lift operational at sea state 4.

This project primarily considers the third and sixth capability elements identified by the task force and to a very limited extent the second.

## **2. Seabasing: Making the case**

Despite America’s successes in the Gulf Wars, the past has seen numerous refusals by Middle Eastern states to allow U.S. forces the use of land bases on their

sovereign territory. In recent history, a few of the Middle Eastern states denied the United States use of their bases to respond to Iraqi attacks on the Kurds. Specifically, Turkey prohibited the United States from using them as a path to Iraq. As a result, the United States could only respond to Iraq's actions with cruise missile attacks against targets in southern Iraq. The denial of infrastructure, whether directly, or by refusing to allow material and combat power to flow across borders, would make such bases entirely useless in a crisis. Moreover, that base infrastructure could subtract from the net combat power available to the United States by the denial of the considerable investments made in the maintenance and logistical facilities to support the projection of U.S. forces (Defense Science Board, 2003).

### **3. Seabasing: Evolving for a new era**

With the end of the Cold War, the Soviet threat to U.S. maritime supremacy also ended, causing the DOD to re-assess their role in a new strategic era. This reassessment provided the movement for resurrecting the seabasing concept, in that the underlying premise of U.S. sea power changed from “The fundamental purpose of naval forces is to achieve command of the seas” to “The fundamental purpose of naval forces is to use command of the seas.” (King & Berry, 2008).

This change in premise spawned a post-Cold War naval intellectual renaissance, reflected in several Department of the Navy (DON) “white papers.” First among these was “The Way Ahead”, which argued for a new pattern of deployments and force composition to maintain the forward presence required to support humanitarian assistance/disaster relief, nation building, security assistance, peacekeeping, counter-narcotics, counter-terrorism, counterinsurgency, and crisis response (King & Berry, 2008).

Seabasing also promises to be an effective way to provide significant operational support to other critical missions such as disaster relief, humanitarian aid, and police enforcement activities – see Figure 2. In early 2005, only two weeks after the enormity of the Indian Ocean tsunami crisis had become clear, almost fifteen thousand U.S. military personnel were providing humanitarian relief throughout the affected region. These American servicemen and service women were supported by twenty-five U.S. Navy ships

and one Coast Guard cutter acting as temporary sea bases for forty-five fixed-wing aircraft and fifty-eight helicopters. By this point in the mission, the U.S. military had delivered 2.2 million pounds of relief supplies to the worst-hit nations, including sixteen thousand gallons of water, 113,000 pounds of food, and 140,500 pounds of other relief supplies during the previous twenty-four hours alone (Elleman, 2007).



Figure 2. ASE Disaster Relief, Humanitarian Aid and Police Enforcement Operations  
Images from: (Lozano, 2009)

Throughout the humanitarian mission, U.S. forces dealt with force protection on an ongoing basis. Marines were careful to stay out of the north and east, so as to avoid the Liberation Tigers of Tamil Eelam. In that case, Indian forces were assigned to work in areas controlled by the guerrillas. Given the ever-present force protection and cultural concerns, the U.S. Navy's ability to remain offshore on the sea bases decreased the American footprint, reduced friction, and facilitated achieving the mission's objectives. Seabasing helped eliminate unwanted accidents or incidents, even as U.S. Navy assets relayed ashore over four hundred thousand gallons of fresh water and over ten million pounds of food and supplies, and handled the treatment of thousands of patients.

#### **4. Seabasing: Operational Validation**

Even if the United States could retain the necessary land bases and port infrastructure to support forward deployed forces, they would still be vulnerable to strikes which could reduce or neutralize their utility. Precision strikes, weapons of mass destruction, and cruise and ballistic missiles all present threats to our forward presence, particularly as stand-off ranges increase. Only those who have read deeply into the history of American military operations in the Second World War understand fully the difficulties that U.S. forces confronted in the early months of America's participation in that war. Throughout 1942, American forward operating bases were under constant attack by the air, ground, and naval forces of the Axis. Such attacks took a severe toll on the defenders. In June 1942 the crucial naval base at Midway Island in the Central Pacific came under heavy air attack by aircraft launched from Japanese carriers, destroying much of the island's infrastructure (Defense Science Board, 2003).

The potential for anti-access by direct attacks is a threat that confronts all armed services over the coming decades. It has major implications for the Army which is devoting substantial resources to developing new capabilities and weapons systems to speed up deployment of its units. To a considerable extent, those capabilities are predicated on airlift being available and on access to land bases to which Army units can deploy in order to begin ground operations against the enemy. Anti-access capabilities obviously also have considerable implications for the use of ports and other fixed facilities by the Navy and the Marine Corps.

However, in a major shift in its approach to movement-to-contact with the enemy, the Army, on two separate occasions over the past decade, has used the sea base as the primary capability for that movement. In Haiti, an aircraft carrier was the sea base for a brigade of the 101st Airborne Division, while during the recent Enduring Freedom operation the carrier, Kitty Hawk, provided a secure base for Special Operations Forces (SOF) units to move in and around Afghanistan (Defense Science Board, 2003).

Reinforcing the importance of seabasing are the logistical requirements that will, for the foreseeable future, make some form of seabasing essential during the conduct of U.S. military operations. For example, the deployment of one of the Air Force's

Expeditionary Air Forces represents an enormous logistical task. The deployment of thirty aircraft to Qatar in 1997 required the movement of 4,000 short tons of personnel, munitions, force protection, and other supplies. Additionally, as most of the forward operating bases from which U.S. forces will have to operate in the future will not possess a sophisticated infrastructure, the difficulties involved in relying on land bases become even clearer. The problem of supplying fuel alone represents an intractable problem and when we think about the tonnages of weapons, sustenance for supporting troops, and maintenance supplies required to support such forces, a picture of the difficulties involved in deploying U.S. military power by air become readily apparent (Defense Science Board, 2003).

## **5. Seabasing: Summary**

The projection of military power from North America has in the past, and will in the future, represent a number of difficult problems. The permanent stationing of U.S. forces abroad will become more difficult to sustain. The political costs of such bases will likely rise, as will the likelihood of attack of such forces by ballistic missiles, terrorism, and weapons of mass destruction. Taken together, the pressures against the permanent forward basing of U.S. military forces have profound implications for U.S. strategy, power projection capabilities, and alliance relationships. The strategic and political framework also suggests the need for seabasing to become a truly joint concept with capabilities allowing for the projection of the full capability of United States.

## **B. OPERATIONAL ANALYSIS**

While the team efforts were initially inspired by the formal AOA process in general, numerous assumptions and simplifications were made to those guidelines to enable a successful project within the constraints placed on the project team. Many of the assumptions made by the team, along with additional scope and bounds information, are described below.

### **1. Operational Scenarios**

The full Range of Military Operations (ROMO) performed by the U.S. military, is quite substantial and is described in Joint Publication (JP) 3-0 on “Joint Operations” (CJCS, 2008). The full list of joint operations is listed in Figure 1-2 of JP 3-0 and is reproduced in Table 1.

Table 1. Types Of Military Operations

Major Operations	Support to Insurgency
Homeland Defense	Counterinsurgency Operations
Civil Support	Combating Terrorism
Strikes	Noncombatant Evacuation Operations
Raids	Recovery Operations
Show of Force	Consequence Management
Enforcement of Sanctions	Foreign Humanitarian Assistance
Protection of Shipping	Nation Assistance
Freedom of Navigation	Arms Control and Disarmament
Peace Operations	Routine, Recurring Military Activities

Examining twenty operations was far beyond the scope of this project. To simplify, the team selected four general mission scenarios for consideration that the team felt were representative of the major types of operations an ASE would be expected to encounter based on the discussions the team had with stakeholders and the documents reviewed. The operational scenarios considered, listed in the order the team initially felt were most relevant to this study:

**a. Major Combat Operations**

A combat mission is a purely military operation where the likelihood of a violent and threatening environment is high. A combat mission involves transporting troops, combat equipment and supplies to a potentially hostile environment. Speed and combat capability are important. An existing infrastructure to support offload cannot be assumed. Forcible entry into the area against armed resistance is a possibility. The essence of the mission is to take the combat troops, equipment including heavy equipment such as Abrams tanks, and supplies rapidly from the sea base to the destination, offload quickly, and leave. There is also the possibility of bringing the troops and equipment back at a later time or of bringing people (such as wounded) or other items back on the return trip to the sea base. The most similar mission from the ROMO is Joint Operations Mission – Major Operation. (CJCS, 2008).

**b. Police Enforcement Operation**

The police enforcement mission involves taking a smaller amount of troops (compared to the combat mission) and their equipment to an area for the purposes of

police enforcement. It is assumed the area is already secured to some degree meaning it is not in open combat. Forcible entry is not considered necessary. It is expected the equipment will be light combat equipment (High Mobility Multipurpose Wheeled Vehicle -HMMWV or Humvees, personnel transports, etc.) as opposed to heavy equipment (tanks). The possibility of personnel having to operate from the vessel, at least temporarily is considered. The most similar mission from the ROMO is Joint Operations Mission – Peace Operation. (CJCS, 2008).

**c. Humanitarian Aid**

A humanitarian aid mission involves bringing supplies such as food and medicine and possibly personnel such as aid workers to an area of need. While any area may contain a threat it is assumed the environment is essentially benign or non-hostile. Cargo and personnel capacity are key factors of importance. An existing port, austere or better, is considered likely. The possibility that personnel may have to operate from the vessel is considered. The most similar mission from the ROMO is Joint Operations Mission – Foreign Humanitarian Assistance (CJCS, 2008).

**d. Natural Disaster Relief**

A natural disaster relief mission is similar in nature to a humanitarian aid effort. The major difference is that it cannot be assumed that any port capability exists. As such, an ASE must be capable of delivering its personnel and goods without external support. The most similar mission from the ROMO is Joint Operations Mission – Foreign Humanitarian Assistance. (CJCS, 2008).

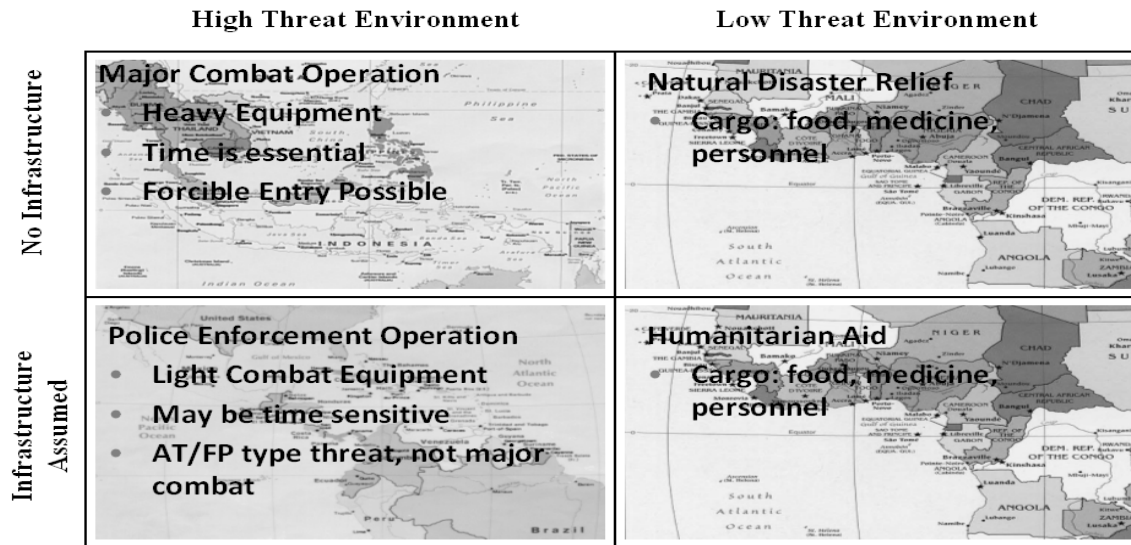


Figure 3. Missions under consideration

As shown in the Figure 3, the four missions differ in two major aspects: 1) whether the destination is a high threat environment or not, and 2) whether an existing port infrastructure can be reasonably assumed. The team felt that these two dimensions of the problem were key differentiators that would impact ASE capability requirements.

Due to time and resource constraints, while all four missions were considered, the team did not thoroughly investigate all of these operational scenarios. The team considered the highest level requirements for each mission, but was only able to perform a detailed analysis using two of these scenarios. The two scenarios selected were the Major Combat Operation and Humanitarian Aid as the missions with the most and least stringent requirements, respectively in the two dimensions considered.

## 2. Assumptions

The team had to make many important assumptions in the course of the project. Some assumptions were made to ensure that the project effort was scoped appropriately and could be accomplished in the time frame available. The following are some of the assumptions related to scope made by the team.

One major assumption is the validity of the seabasing concept itself. The team has not considered alternatives to seabasing. Enabling the sea base is the central theme of this

project. Based on the research the team performed regarding seabasing, as discussed in the seabasing section above, the team felt this was a safe as well as necessary assumption.

The team has made some assumptions related to the nature of seabasing. For example, it was not clearly defined how far the sea base can or should be from the operational landing point. Based on the teams research it appears that a clear specification does not exist. Most of the seabasing scenarios described in the literature have the sea base at least twenty-five nautical miles (nm) from land. The team assumed that farther is better (up to a point) due to the advantages obtained in maneuverability and safety of sea base assets. Therefore, for the purposes of the team's analysis, the sea base will be located no closer than 25 nautical miles and no further than 250 nautical miles from the objective.

Similarly, the team has not considered all of the many technical obstacles that must be overcome to fully enable the sea base. There is a great deal of research currently underway related to seabasing enablers, such as platform stability and ship-to-ship transfer technologies. While the team has considered the work being done in those areas, particularly with regard to how it affects transport of the cargo to its final destination, the focus of our project is on the transport capabilities and systems that move cargo from the sea base to its destination. As such the team has assumed that cargo transfer and other sea base capabilities will exist and that the necessary cargo can be safely and effectively transferred between the sea base and the ASE platform.

The focus of the effort is on the Concept Development stage of acquisition and a simplified AOA culminating in a recommended approach for ASE. The team considered alternatives from a high-level, functional perspective. Due to time constraints the team was limited in its ability to validate all information collected regarding the potential ASE alternatives. The team collected available information on potential alternatives for ASE and, with basic checks for reasonableness, has largely assumed the information collected regarding the various systems is reliable.

### **3. Primary Areas of Focus**

Detailed engineering analyses, naval architecture or other detailed engineering work is beyond the scope of this effort. The bulk of effort by the team has been on

collection, analysis and validation of operational needs, functional analysis based on those operational needs, consideration of possible alternatives compared to the collected requirements, prioritizing the alternatives based on stakeholder priorities and selection and documentation of a preferred alternative. The team did not design any ASE solutions nor even really suggest modified alternatives. The team collected information on current existing or planned systems that might be appropriate alternatives for an ASE capability. The approach taken by the team in its analysis is discussed in more detail in Chapter III.

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### III. FORMULATION

As mentioned in the Chapter II, the Formulation step in the systems engineering process is used to clearly identify the problem, evaluate the objectives and/or goals of the solution and create potential alternatives and the metrics that could be used to evaluate those alternatives. The following sections discuss the formulation efforts of the team. The team started with an initial problem statement and then developed a revised problem statement based upon research and analysis. The stakeholder's interpretation of the problem was investigated, requirements were identified and relevant constraints that impact the problem were captured. Additional activities included mission analysis and identifying operational scenarios.

#### A. INITIAL PROBLEM STATEMENT

The initial problem statement was identified through discussions with the Office of Naval Research (ONR) regarding their Innovative Naval Prototype Transformable Craft (T-Craft) project. ONR had contacted NPS seeking assistance and input regarding ONR's T-Craft project. The T-Craft project is a Research and Development (R&D) effort seeking to develop a "game changing" capability in support of seabasing. The T-Craft vision is described in more detail later in Chapter III. The ASE team met with the ONR project manager and support staff to discuss T-Craft and what systems engineering work would be of value to ONR. Going into this meeting, the team's initial problem statement was as follows:

*To enable seabasing a Transformable Craft connector vehicle is needed that can self deploy over long distances while unloaded, can carry 300 – 750 LT of cargo, has a fully loaded range of 500 nautical miles at 40 knots, supports cargo transfer in high sea states, can traverse sand bars and mud flats and is fully amphibious for "feet dry" landing capability.*

In essence, the initial problem statement was the T-Craft project vision. In discussion with the ONR staff it became clear that ONR desired help developing a

“business case” for the T-Craft. After meeting with ONR, the team discussed project possibilities and came to the conclusion that the problem statement would not work as it was. The team would not be able to use the initial problem statement and still follow a reasonable systems engineering process since the results must be based upon impartial requirements, functional and decision analysis.

Since a business case did not exist at the time for T-Craft, the team would be assuming the conclusion and then trying to validate the need for T-Craft. The team felt strongly that a more objective problem statement was needed and decided to broaden the project’s stakeholder portfolio to collect information on requirements and identify a more general problem statement that would help answer the T-Craft question but in a more open, systems engineering manner.

## **B. STAKEHOLDERS ANALYSIS**

Stakeholders are people and groups not directly involved in the development project but are affected by it in some way and have a vested interest in its outcome. As noted by Sage & Armstrong, “stakeholders will usually be owners, users, customers, clients, managers, maintainers, administrators and regulators” (2000). As a result, they and their views must be addressed by the project manager and the sponsor. The most important type of stakeholder is the user—those people who will be using the end product. The team classified stakeholders into primary and secondary categories. Primary stakeholders are the individual groups that are responsible for defining the needs of the ASE system and making the decisions regarding ASE solutions. Secondary stakeholders are the other groups or individuals with a vested interest in the system.

The project team conducted a brainstorming session to develop an initial rough draft list of the stakeholders for this project. The initial stakeholders were then further refined and specific contacts were obtained for as many of the areas identified as possible. The following lists the potential primary and secondary stakeholders identified by the team.

**Primary Stakeholders:** Since seabasing is a broad capability with broad influence, this includes operational commands of most of the major services (minus Air Force) and special operational commands:

- Navy operational commands
- USMC operational commands
- Army operational commands
- Special Operations Command (SOCOM)
- Joint Forces Command (JFCOM)
- Transportation Command (TRANSCOM)

Note that requirements generating organizations (such as OPNAV for the Navy) are included under these operational commands.

Secondary Stakeholders were identified that supported seabasing through a variety of means such as building the ships involved or supporting the major operational commands:

- Naval Sea Systems Command (NAVSEA)
- Marine Corps Combat Development Command (MCCDC)
- Navy Supply Command (NAVSUP)
- Marine Corps Logistics Command (MARCORLOGCOM)
- Office of Naval Research (ONR)
- Tank and Automotive Command (TACOM)
- Combined Arms Support Command (CASCOM)
- Surface Deployment Distribution Command (SDDC)
- Military Sea Lift Command (MSC)
- Army Watercraft Systems (AWS)
- North Atlantic Treaty Organization (NATO)
- United States Coast Guard (USCG)

The team performed stakeholder interaction utilizing a tailored Stakeholder Analysis process shown in Figure 4. This iterative process includes the identification of

key stakeholders followed by a consolidation of their needs, wants, and desires for the ASE system resulting from personal interviews, research of relevant documents (including publications and conference presentations), operational lessons learned, phone conversations, and email. Of note, selected members of the team attended the T-Craft CONOPS workshop conducted on May 21, 2009 at the Aerospace System Design Laboratory, Georgia Institute of Technology. The team presented the work accomplished to date and gathered information regarding sea base enabler objectives, needs, wants, and desires from the stakeholders who attended the workshop.

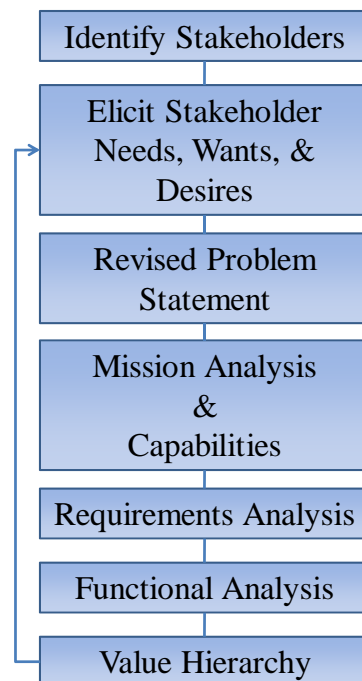


Figure 4. Iterative Stakeholder Analysis Process

In addition to interaction with major stakeholders representing user perspectives the team also collected information on several potential alternatives from NAVSEA program offices but did not discuss needs, wants and desires with them. The team conducted in-depth conference calls or meetings with several of the stakeholders and this information aided greatly in the refinement of the needs, wants and desires and development of respective requirements documentation. A questionnaire was sent to the stakeholders in an attempt to further define objective and threshold metrics. The entire

questionnaire can be found in Appendix C. The following are some of the key questions posed by the survey:

- What value do you expect to gain from the sea base?
- Is there a capability gap with current military cargo platforms that would limit transportability from a sea base to the insertion point? Please describe in detail.
- What operational scenarios to you see the need for an advanced sea base enabler (ASE)?
- Based on previous military operations what is the one operational characteristic that could make the ASE indispensable.

The team intended to use the stakeholder questionnaire as a basis to eventually determine common requirements, identify agency specific requirements, identify requirements overlap and refine the initial problem statement. However, from the questionnaires sent out, the team received limited useful information. ONR and other attendees provided feedback at the T-Craft CONOPS meeting. While reviewing inputs from the stakeholders the team identified common interests regarding the capabilities of a sea base enabler, which include:

- Each stakeholder saw the need to reduce the footprint (logistics footprint) ashore as the main value of a sea base.
- Some capability gaps mentioned were Operational speed (“the faster the better”), Command and Control (C2) interoperability, range, skin to skin transfer, and draft issues.
- Stakeholders indicated the ASE must operate in a sea state 4.
- The system must be able to utilize modern ports, austere ports, and unimproved landing areas to support all potential missions.

## **C. REVISED PROBLEM STATEMENT**

As mentioned previously, ONR indicated that they had a need for a “business case” to support detailed development of a T-craft solution as a sea base enabler. Preliminary team research suggested that there are several sea base enabler efforts underway so T-Craft may not be the only possible solution. Due diligence and proper systems engineering methodology suggested that the problem statement needed to be broadened and generalized and should be based on major stakeholder input. Based on team discussion with ONR as well as with other stakeholders mentioned above and reading collected resources on seabasing, the team developed a revised problem statement:

*For a sea base to be truly beneficial a capability must exist that supports efficiently transporting needed materiel from the sea base to the desired debarkation point. The capability must support peace-time, non-combat operations’ and war-time, combat operations’ logistics and support needs. The solution must be cost effective and capable of operating under all environmental conditions, including sea states, under which necessary military operations are expected to take place and must support a transport rate sufficient to ensure materiel is delivered within operational time limits.*

The new problem statement is more general and more accurately reflects the need as indicated by the stakeholders and source documents identified. Some key differences between the initial and revised problem statements are:

- The revised statement focuses on a needed capability as opposed to a platform.
- The revised statement focuses on the missions that must be supported as opposed to functional requirements.
- The addition of cost effectiveness as a need.
- The addition of key operational needs.

The revised problem statement, as shown above, became the working problem statement for the project.

#### D. MISSION ANALYSIS

As mentioned in the Scope section of this report, the ASE team selected four general mission areas to examine for the purposes of this project and ultimately ended up analyzing alternatives against two of those missions. One of the more challenging aspects of this project was determining the most appropriate missions against which to evaluate an ASE. The primary reason for this is that an ASE has the potential to provide value for a wide variety of mission areas and stakeholder perspectives on mission priorities tended to diverge along two lines. Figure 5 shows a view of the Range of Military Operations (ROMO) plotted as a function of intensity versus frequency. What is important to note in this figure is that the most intense or dangerous (and most demanding from a functional systems perspective) missions are also the least likely/frequent missions. This was also highlighted in a brief by TRANSCOM at the T-Craft CONOPS meeting (Pattan, 2009). A slide from that brief is shown in Figure 6 and depicts that 75% of the missions they perform are non-combat missions. TRANSCOM also indicated that they found the non-combat related missions to be “40% harder” although exactly what that meant was never clarified.

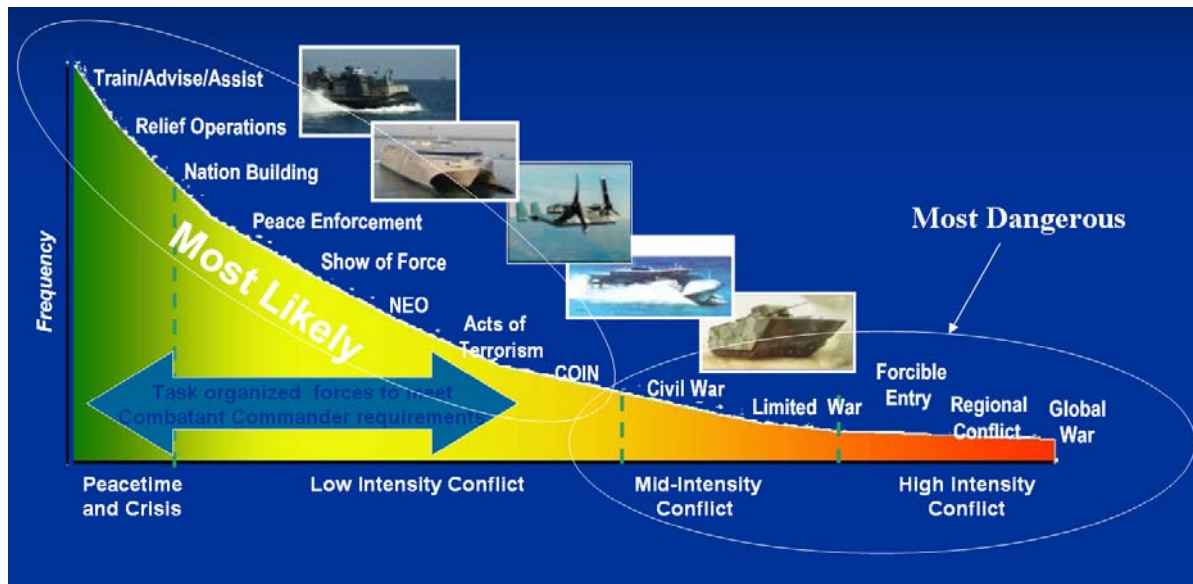


Figure 5. ASE Operation Types  
Image from: (Lozano, 2009)



Figure 6. Mission Types  
 Image from: (Pattan, 2009)

Stakeholder input indicated divergent views regarding what missions, and correspondingly what capabilities are needed to support those missions. When discussing capabilities with stakeholders with a traditional war-fighting point of view (USMC, Army) their focus was to support major combat operations and thus have a system that was suitable for those missions. Essentially these stakeholders want a combat vessel that can carry supplies. Conversely, when discussing missions and capabilities with stakeholders representing logistics functions, their primary focus was on non-combat missions.

The challenge for the team was to determine an appropriate mission set and functional requirements that satisfied a broad spectrum of potential needs. The risk was that if the team focused on the combat mission needs there was the risk of developing a "gold plated" solution that was far more capable and expensive than what was needed for

the majority of missions in which the system might be utilized. If the team focused on the logistics needs, however, there was a risk that the system might not meet the needs for the critical combat missions.

As described previously, the team developed four general missions for analysis purposes. The team chose to focus on two missions that represented each mission type for decision analysis purposes. The major combat operation is obviously representative of a combat mission. The Humanitarian Aid mission is representative of a non-combat, logistics mission. By judging potential alternative systems against these two missions, the team felt that recommended alternatives that met both sets of mission capabilities could be found.

The Scope section above provided a basic description of the two missions. The following sections provide more detail including discussion of the types of functional requirements that are most important for each mission.

### **1. Major Combat Operation**

Chairman of the Joint Chiefs of Staff Joint Publication 3-0 on “Joint Operations” does not specify any mission specifically called Major Combat Operation (MCO). For the purposes of this project a MCO is a mission in which a large number of forces are involved and significant combat is expected. The conflict is not a police action or a small, localized combat effort. The mission involves assembling and employing significant amounts of troops and materiel for the purpose of combat. Some of the primary characteristics of this mission that affect the functional requirements of an ASE are:

- High threat, hostile environment. The ASE will be expected to operate in an environment where it may encounter significant military threats to itself and its cargo.
- Speed. There may be a need to rapidly employ the troops and materiel carried by the ASE so speed of embarking, transit and disembarking are important.
- Support transport to all types of terrain including destinations with no port facilities (such as a beach).

- Support transport of combat ready troops and their equipment as a unit.
- Operate in any environmental conditions that will support normal military operations.
- May be required to make a forcible entry on a defended position/beach, either operating with other crafts or independently.

To summarize, to meet this mission an ASE must be capable of delivering combat ready troops, as an operational unit, to almost any water bordering location, rapidly and safely under hostile and potentially adverse weather conditions.

## **2. Humanitarian Aid Mission**

Humanitarian Aid is an increasing part of the armed forces mission. For the purposes of this project Humanitarian Aid is distinguished from Natural Disaster Relief. The major difference between the two missions is that for Humanitarian Aid it is assumed that reasonable port facilities (at least an austere port and probably better) exist and can be utilized. The Humanitarian Aid mission consists of delivering food, water, medicine and other necessities along with personnel (such as medical personnel) to an area of need. Primary characteristics of this mission that affect ASE functional requirements include:

- Predominantly low threat environment. Security threats might be on the order of protecting personnel from mobs seeking food.
- Cargo capacity is important. There is the potential to bring in huge quantities of supplies. For efficiency, significant cargo capacity is desirable.
- May need to transport significant quantity of non-combat, non-military personnel. There is also a possibility that personnel may need to be berthed on board during operations.
- Speed can be a consideration for the Humanitarian Aid mission in some cases. For example, when quick response may prevent additional death or injury to the aid recipients.

Summarizing this mission, the ASE must be able to transport large quantities of supplies and support personnel to essentially safe locations, provide basic security for personnel and possibly berthing for personnel.

## **E. REQUIREMENTS ANALYSIS**

The team identified the requirements for materiel assembly and transport from the sea base to the area of operations through interaction with stakeholders as described above, extensive literature review and analysis based on the team members' experience. The following describes the requirements generation and key parameter and metric selection process along with the key parameters and rationales.

### **1. Requirements Definition Approach**

To continue the development of the requirements for this project, the team members also conducted an extensive literature search in parallel to the stakeholder analysis. Each of the documents listed in Appendix A was reviewed by two or more team members. From these documents a preliminary list of requirements was developed. The team then reviewed the preliminary list and produced a consolidated list of potential requirements parameters.

The complete list of the requirements with threshold and objective values is captured in a Microsoft Excel file. Table 2 lists these requirements, but the threshold and objective values are not listed as they are mission specific.

Table 2. Requirements

<b>Un-Refueled Range (No-Cargo, 20kt)</b>	<b>Land Grade</b>
<b>Un-Refueled Range (Loaded, 20kt)</b>	<b>Crew Size</b>
<b>Un-Refueled Range (Loaded, 40kt)</b>	<b>Vehicle Side Ramp Angle</b>
<b>Beachable / Beach unload</b>	<b>Ramp Length</b>
<b>Un-Refueled Range (Overland)</b>	<b>Discharge Method</b>
<b>Max Speed (water borne)</b>	<b>Discharge Areas, normal</b>
<b>Seabased Cargo Operations</b>	<b>Discharge Areas, extreme</b>
<b>Survivable</b>	<b>Draft, unloaded</b>
<b>Normal Operations</b>	<b>Draft, fully loaded</b>
<b>Cargo Payload Weight</b>	<b>AT/FP</b>
<b>Cargo Payload Area</b>	<b>Armor (ballistic)</b>
<b>Cargo Payload Max Height</b>	<b>Self-Defense / Countermeasures</b>

<b>Deck Loading</b>	<b>Offense</b>
<b>Cargo Transfer Capability</b>	<b>Built in Wash-Down capability</b>
<b>Crane ops</b>	<b>Signature</b>
<b>RO/RO</b>	<b>Communications</b>
<b>Vertical Lift</b>	<b>Covered Cargo Area</b>
<b>Clearance (for land ops)</b>	<b>Berthing</b>

Discussion of the requirements parameters and rationale for selected threshold and objectives values are documented in section 2. At the time the initial requirements analysis was performed, the team was still considering the four general missions areas described previously and this is reflected in the following discussion.

The ASE Requirements spreadsheet consists of a list of requirements parameters followed by threshold and objective values for the parameters based on one of the four mission types identified for analysis: Major Combat Operation, Humanitarian Aid, Police Enforcement and Natural Disaster Relief. The threshold values are the values that must be met in order to meet operational requirements. They represent the minimum acceptable value. Objective values are the desired values that would give the best expected performance for the mission. The four missions are listed separately as the team expected that each mission would have significant differences in requirements that would be reflected in the threshold and objective values for the requirements parameters. For this reason, it was decided that each mission would be analyzed independently with regard to the potential ASE alternatives.

The stakeholders and team members did a comparative analysis of the various individual platform requirements in order to determine the essential global requirements the ASE would need to meet for the multiple mission sets. This analysis was done via a ranked survey that allowed the stakeholders and team members to assign a value from 0 to 10 for each requirement within a specific mission. A value of 0 indicates the parameter is not essential while a value of 10 is considered key. All the data was compiled and initial requirements were ranked. In an effort to keep this project within scope and meet essential deadlines the six parameters that seemed most important to stakeholders across missions were selected as the global requirements and were employed in the decision analysis process as discussed in the interpretation section.

## **2. Initial Requirements**

The team initially identified requirements in several areas. These areas included ranges, sea states, cargo capacity and transfer options, and additional operational vessel characteristics. These initial requirements were developed during the early stages of this project and were based upon the team's initial review of existing seabasing documentation and preliminary interaction with the stakeholders. As the project evolved and moved through the analysis phases the team chose a smaller sub-set of requirements on which to concentrate their research efforts. The initial requirements and the team's rationale for why a specific requirement is relevant and how threshold and objective values were selected are described below. While the team considered airlift as an alternative, the majority of the requirements discussed are relevant to sea based platforms. The air lift alternative and rationale for why it was not analyzed in depth are discussed later.

### **a. Un-Refueled Range (self-deployed range) (No-Cargo, 20 knots)**

The un-refueled range of the system, when not loaded with cargo, is directly related to its ability to self deploy. The higher the range the more capable the system is of self deploying to different operational areas of the world where it might be needed. Since range is affected by speed due to varying fuel consumption rates at different speeds it is necessary to specify the range for a specific speed. The team chose 20 knots as a reasonable cruising speed. Based on the teams' literature review, a range of 2500 nautical miles was selected as the objective value which would allow the ASE to self deploy to most potential operational areas from U.S. controlled bases around the world. A threshold of 1,000 nautical miles was established as a minimal, meaningful self deploy range that would allow for an ASE to transit to a forward location.

### **b. Un-Refueled Range (Loaded, 20 knots)**

For mission execution the team considered range of the system while fully loaded. For missions where speed is not as essential (essentially non-combat for the purposes of this project) an un-refueled range at a nominal cruising speed of 20 knots is considered. Based on the literature review on seabasing it appears that the maximum distance generally considered for a sea base is about 250 nautical miles. This was used

for the objective value for this parameter to place the sea base over the horizon and out of harms way. The threshold was set at 25 nautical miles as a reasonable minimum.

**c. Un-Refueled Range (intra-theater range) (Loaded, 40 knots)**

In some cases, particularly combat missions, there may be a need to transport cargo at high speed. The same rationale applies for the higher speed case (Loaded, 40 knot) as applies to the loaded, 20 knots case shown above. A threshold of 25 nautical miles and objective of 250 nautical miles were used.

**d. Beachable / Beach un-load**

Several of the stakeholders with a combat operations focus indicated the importance of an ASE being capable of delivering its cargo directly to most shore environments, meaning the ability to actually deliver personnel and materiel “feet dry” to a beach. Hence, the ability to deliver directly to a beach without any additional infrastructure is a critical parameter for some missions. For this capability the team felt either a platform could do it or not. As such this parameter is treated as a binary, yes/no parameter. The threshold values change depending on what mission is being considered. For each of the mission areas selected, beachability was evaluated as a threshold or objective value. For both major combat operations, and natural disaster relief, beachability was identified as a requirement or threshold value, for the police action and humanitarian aid it was determined to be an objective, but not a requirement.

**e. Sea based Cargo Operations**

During the initial project scoping meeting with ONR, one of the primary objectives was sea based cargo operations under operational sea states. The team was told that in order to successfully support the sea basing concept, a minimum requirement for full cargo operational capabilities was sea state 3. Therefore we selected sea state 3 as our threshold and sea state 4 as objective during initial project scoping. This is in line with the threshold requirements for the Mobile Launch Platform (MLP) and the future Large, Medium Speed, Roll-on Roll-Off (LMSR) vessels and allows for full capabilities when operating at the sea base. Any reduction in the sea state requirement would limit the versatility and utility of the ASE.

**f. Seakeeping - Survivability**

During the literature review conducted by the team, a sea state of 7 or 8 was shown to be the primary focus. Based on the review and current ship design practices, a sea state of 7 (threshold) for best course and speed and 8 (objective) were chosen as the survivability requirements for the ASE.

**g. Seakeeping - Normal Operations**

The same rationale that was used to determine the initial requirement for survivability was applied to Normal Operations. Normal Operations is best defined as transit and all other at sea operations outside of cargo operations. A sea state of 4 (Threshold) was selected for the ASE to have full mission capability (speed and distance).

**h. Cargo Payload Weight**

The maximum cargo weight selected was to allow the ASE to transport a minimum of four Main battle tanks (M1A1) at approximately 75 LT /per tank. This would allow for 4 tanks and associated equipment to travel together on one ASE and supports the requirement for transporting combat troops as a unit. The values for Humanitarian Aid and Natural Disaster were selected based on the need for heavy infrastructure items and Twenty Foot Equivalent Units, which are the standardized ISO shipping containers. When supporting a civil action, the team decided the ASE would potentially need to carry significantly more palletized or containerized cargo vice combat ready mission selectable cargo. To enable full combat operations, there must be “white space” between vehicles so that selective offload is an option. During a civilian action, selective offload is assumed not necessary, so the “white space” lost for combat load outs would be replaced by additional supplies and materiel.

**i. Cargo Payload Area**

The cargo payload area threshold (2,200 square feet.) was based on the requirement to load and un-load a minimum of four M1A1 Main Battle Tanks. The Objective (5,500 square feet) was set to allow four M1A1 tanks and associated equipment.

**j. Cargo Payload Max Height**

Since the ASE is planned to support a full range of combat and humanitarian efforts, a Heavy Expanded Mobility Tactical Truck (HEMTT) may be

required. The minimum height required to support a HEMTT ( M1075/M1076) Truck and Trailer system is fifteen feet. If the design of the ASE has an enclosed mission deck, then the cargo area must have sufficient height to support the HEMTT and trailer loaded with Twenty Foot Equivalent Units (ISO shipping containers).

**k. Deck Loading**

Unlike the M1A1 Main battle tank, the wheeled combat vehicles in Army and Marine Corps have a very high point load at the wheels. Therefore based on research and analysis of current ship designs, the capstone team selected a threshold of 500 pounds per square foot for deck loading. This will enable the largest number of military vehicles and cargo to be transported by the ASE.

**l. Cargo Transfer Capability**

Cargo transfer capabilities were modeled as binary criteria, Yes/No, for each of the missions for each type of capability based on whether the specific cargo transfer capability would be appropriate. Based on the teams' research and analysis, the threshold value, Yes or No was determined for each mission. The objective value was set to have full Crane, RO/RO and Vertical Lift for all four mission areas.

**m. Clearance (for land ops)**

The clearance selected by the capstone team was based on man-made and natural beach and land obstacles that an amphibious vehicle may encounter when performing operations. A four foot threshold obstacle would allow the ASE to traverse over large rocks and obstructions. Obviously, this parameter is only relevant to amphibious alternatives.

**n. Land Grade**

For amphibious alternatives, a five degree land grade threshold value was selected to allow the ASE to transit most beach areas when in air cushion vehicle configuration. The land grade value was selected based on the literature review conducted by the team and on the design of existing and future air cushion vehicles. The objective value of seven degrees would exceed existing capabilities. This land grade was based on historical requirements of previously designed hovercraft vehicles.

**o. Crew Size**

A minimal crew size is desired based on stakeholder input. The crew size selected was based upon reduced manning requirements. If the mission requires a forcible entry craft, then the ASE would potentially require additional personnel to man offensive and defensive weaponry. Manning is a large contributor to Life Cycle Costs (LCC) and any reduction in manning, even a single billet, will have a significant impact upon LCC.

**p. Vehicle Vertical Ramp Angle**

The ramp angle provided is consistent with current design requirements and is set to allow military vehicles to easily embark/debark the ASE. Depending on the configuration of the sea base, the ramp angle will need to allow interface with the various ships of the sea base as well as the different points of debarkation.

**q. Vehicle Ramp Slew Angle**

A 40 deg slew angle will allow the ASE to work in an Austere port environmental as well as with a quay wall. This will allow for side mooring and enable the ASE to perform full mission on-load and offload. The ASE may also need to have the ability to offload either from the front or the rear depending on the design requirements.

**r. Ramp Length**

A 30 ft. ramp length was selected as a threshold value by the capstone team to allow for vehicle offload to the largest possible locations, the longer the ramp length, the greater the allowance for cargo offload particularly for non-amphibious vessels.

**s. Draft, un-loaded / fully loaded**

The draft selected for the ASE was primarily based on the the beachability requirement and whether it was required for a specific mission. If beaching is not required then a draft not to exceed 15 ft is required to allow the ASE to operate in austere port environments. However, if a mission requires the ability to beach then it will require a smaller draft, or no draft at all when it converts to amphibious mode. The maximum draft of 12 feet was selected for a beachable craft assuming the ramp would then project to the beach and the cargo would be offloaded “Feet-dry”. For beaching craft, the smaller the draft the better.

**t. Combat Systems**

The ASE is assumed to have the capability for crew served weapons. The Anti-terrorism / Force protection (AT/FP) capability is just the ability to mount weapons in specific locations when the ship is operating in an environment where AT/FP is required. Depending on the employment and if the ASE is considered a forcible entry craft, then more robust self-defense and offensive capability may be necessary. Possible levels of combat systems that the team considered include:

- AT/FP Compatible – support carry on of AT/FP capabilities. For example, 50 caliber machine gun mounts.
- AT/FP Integrated – has AT/FP weaponry fully integrated and always available.
- Armor (ballistic) – to provide protection from ballistic weaponry.
- Self-Defense / Countermeasures – examples include chaff and flares.
- Offense – offense includes more capable weaponry than covered by AT/FP. For example, 5 inch guns or small missiles or rockets.

**u. Built in Wash-Down Capability**

The built in wash down capability is specifically for cleaning of vehicles that are being returned to the ASE after operations. The ASE is not assumed to be NBC capable, but the objective would be to allow the ASE to have an organic capability to clean vehicles and equipment prior to them returning to the ASE, and subsequently returning to the sea base. Stakeholders indicated it was required to de-contaminate the vehicles in the field.

**v. Signature Reduction**

Reduced signatures were considered as a possible requirement. The ASE is not required to have any signature reduction. Under various operational concepts, the ASE is considered a combat capable craft. Under those operational scenarios the ability to have a reduced signature, (IR, magnetic, etc.) may be desirable, but is at best considered as an objective.

**w. Communications**

The minimum communications suite for the ASE is to allow for full operations of the craft at sea, within the sea base, and in any port or beach location. The objective (more robust C4ISR including elements such as Common Operational Picture) would be necessary in a combat role during forcible entry.

**x. Cargo Area Cover (visual or ballistic shielded)**

During discussions with the various stakeholders there were a number of suggestions regarding covering the cargo area. The suggestions ranged from a visually obscuring cover to “camouflage” or mask the cargo load, to full ballistic protection for the cargo area. The stakeholder suggestions included the desire to have protection of the cargo from environmental factors as well as threat factors depending on the employment of the ASE.

**y. Quantity of Berthing**

The berthing numbers selected for the ASE for the Humanitarian Aid and Natural Disaster relief missions were based on the need for a workforce or relief team to be able to operate off of the ASE for a period of time to due to limited local infrastructure.

**F. SYSTEM CONTEXT**

The ASE team analyzed the environment in which as ASE would be expected to operate to identify which external systems or entities the ASE would interact with and what items or information would be exchanged between them. According to Buede, “An external systems diagram is the single most important activity to help define the boundaries of the new system” (Buede, 2000). The team developed an external systems diagram for ASE to aid in understanding how the ASE system would be required to function. Figure 7 shows the external systems diagram that was developed. The diagram is mostly in IDEF0 format with inputs coming in from the left, outputs exiting from the right, controls coming in to the top and mechanisms entering from the bottom (KBSI, 2009).

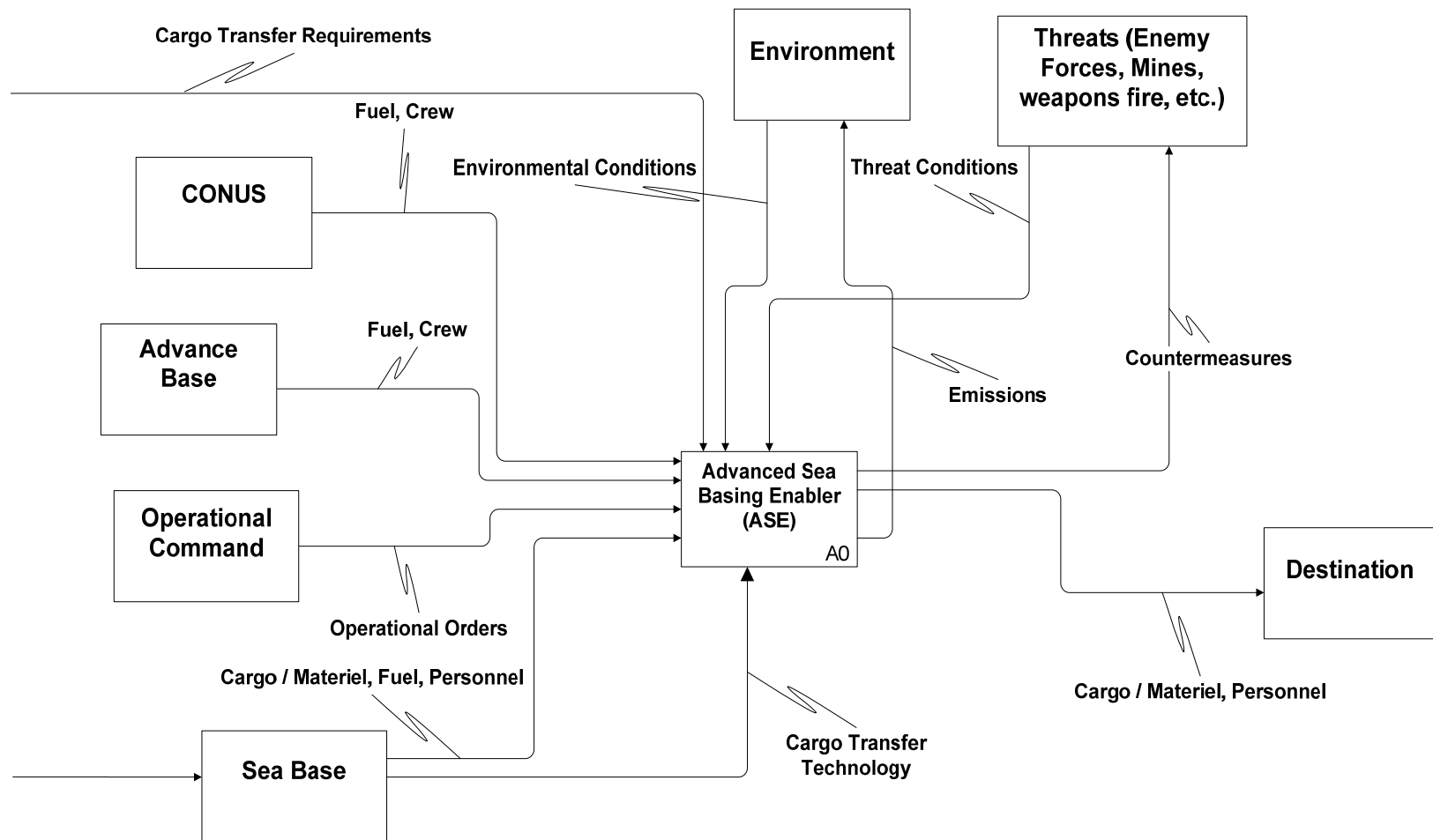


Figure 7. ASE External Systems Diagram

The following describes the elements shown in Figure 7.

## **1. CONUS**

The Continental United States is one of the locations from which the ASE might deploy. Fuel and Crew are expected items that move from CONUS to the ASE. (Note: for deployment the team made the assumption that the ASE generally deploys without cargo. Obviously it could deploy loaded although that would affect its deployment range.)

## **2. Advanced Base**

The ASE might deploy from a forward or foreign base. As above, fuel and crew are the primary items transferred.

## **3. Operational Command**

When an ASE is being used in an operational capacity it will be responsible to some operational command from which it will receive its operational orders.

## **4. Sea base**

The most important external system from the perspective of this project is the sea base. The ASE will take on cargo, fuel and personnel from the sea base. In addition the sea base provides a control, in IDEF0 terms, to the ASE in the form of cargo transfer requirements and a mechanism in terms of cargo transfer technology or capability.

## **5. Environment**

The ASE will operate in some physical environment that will influence how the ASE can operate. Weather is an example of an environmental control. Sea State will influence how and whether the ASE can operate. In addition, the ASE will contribute to the environment in terms of its physical interactions such as gaseous (exhaust) and electromagnetic emissions.

## **6. Threats**

Another element of the environment that is covered separately is threats. As a military vessel the ASE may encounter significant threats as part of its operation. These threats create threat conditions that act as controls on the ASE. The ASE might have the capability to utilize countermeasures of some form in response to threats.

## 7. Destination

Delivering the cargo and personnel it is carrying to some destination is the primary objective of the ASE.

### G. FUNCTIONAL ANALYSIS

Functional analysis is a critical systems engineering activity during which the key functions are identified and analyzed. The team considered the requirements that had been identified and the operational situation in which the ASE would operate, as depicted in the external systems diagram above, and then developed the hierarchical diagram of the three primary (top level) ASE functions, as shown in Figure 8.

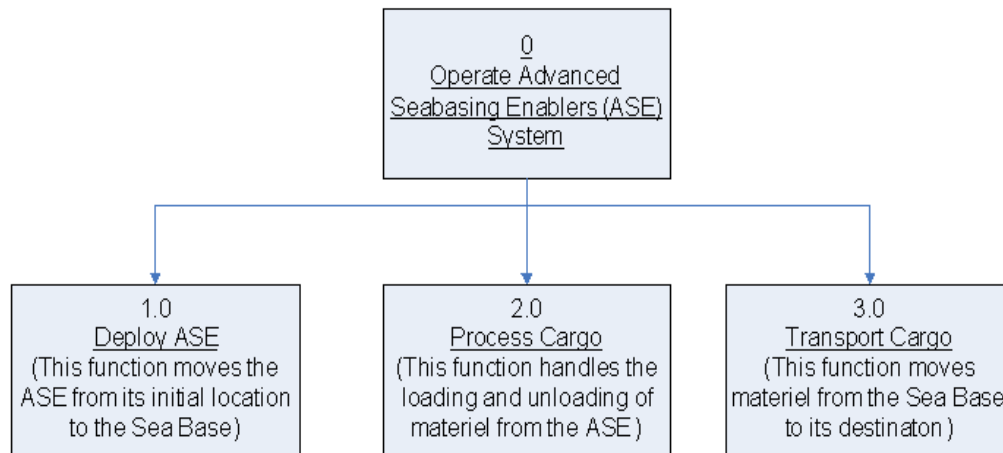


Figure 8. Top-level Functions

#### 1. Deploy ASE

The Deploy ASE function is responsible for getting the ASE from wherever it is stationed to the sea base. The exact nature of this function will depend on the final form of the ASE but all ASE candidates must get to the sea base to perform their mission.

#### 2. Process Cargo

The Process Cargo function includes the necessary activities to load and un-load materiel, personnel and any other items that must be loaded or un-loaded from an ASE and to or from any source or destination with which the ASE would be expected to operate.

#### 3. Transport Cargo

The Transport Cargo function is responsible for moving the ASE, while loaded, from the ASE to its destination, and also possibly from the destination back to the sea base if the ASE is

returning with cargo or personnel. This function may also include elements for dealing with threats.

It should be noted that there are many ways in which a system may be functionally decomposed. The functional hierarchy described here is one way in which the functions of an ASE could be decomposed. The team chose to focus on the logistics functions of the ASE since they are central to its mission. As such, the three top-level functions described represent good top-level functions for an ASE and it makes sense to incorporate sub-functions for dealing with threats as part of the transport function where such threats are most likely to be encountered. It would be equally valid to have a fourth top-level function for responding to threats. Also, as discussed later it is recognized that processing cargo can be significantly different depending on the type of cargo and mission. Top-level functions could have been created to acknowledge this. However, the team felt that the three top-level functions chosen were a good representation of the top level functions for an ASE.

The team did additional analysis to decompose the top level functions. The team noted that there can be significant differences between how the ASE platform must behave depending on whether it is executing a combat or non-combat mission. As such, each function was decomposed into combat and non-combat versions as shown in Figure 9. The team felt that for the purposes of this project, decomposing Deploy ASE and Transport Cargo by combat or non-combat mission was sufficient. Process Cargo, on the other hand, required some additional decomposition to understand some of the nuances of this function. The team recognized that the processes for loading and un-loading cargo, while similar in some respects, could also have significant differences and hence should be distinguished. Loading will take place at the sea base, a hopefully benign environment from a combat perspective. Un-loading cargo could potentially take place in a variety of physical situations (port, austere port, beach, etc.) and could also be performed in a potentially hostile environment.

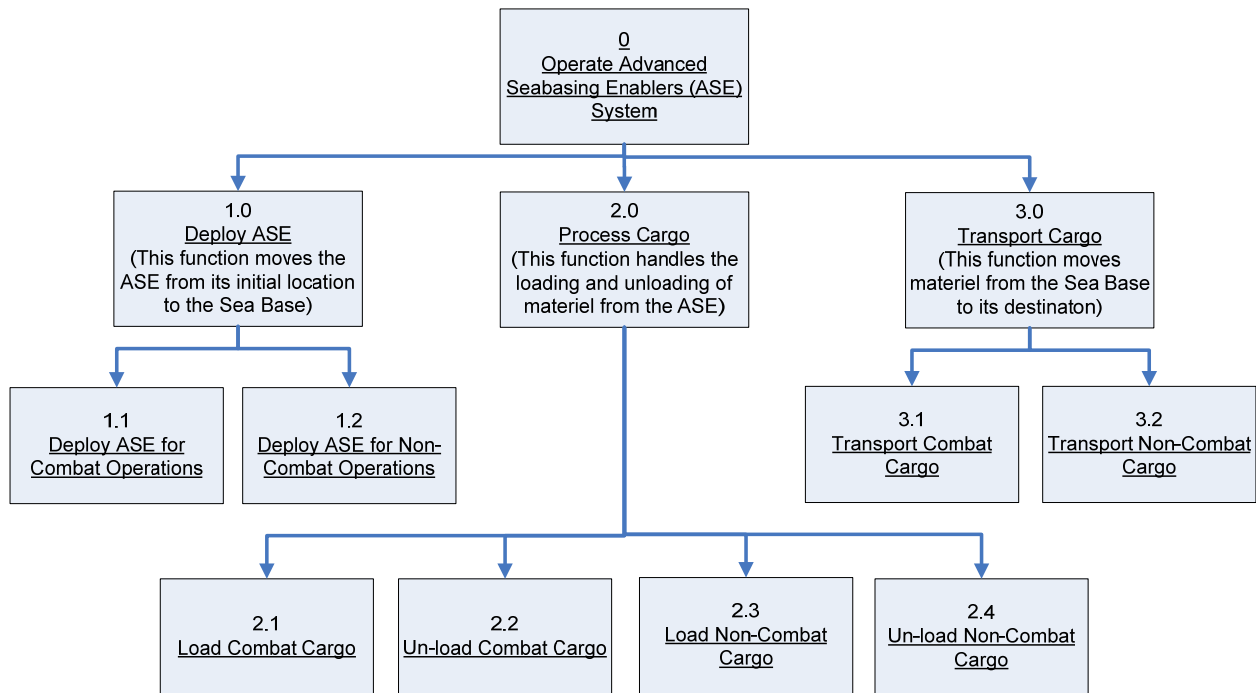


Figure 9. Functional Decomposition

The cargo sub-functions are also decomposed based on whether the cargo is a combat or non-combat load. Non-combat loads are likely to be dominated by items such as ISO containers, pallets, etc. and may be packed more tightly than combat loads. Combat loads may be similar but also may be combat ready units ready to roll off the ASE and into action, a very different un-load process than un-loading pallets.

In addition to the function requirements the team also considered non-functional requirements (INCOSE, 2006). In a systems engineering effort the non-functional requirements can play a major role in selecting a final solution. Non-functional requirements such as availability, reliability, maintainability and interoperability often are key attributes that define system performance.

While non-functional requirements are important features of most systems, the team did not have the time to conduct any analysis on these requirements other than to identify some of the requirements that could be important. These requirements are shown in Figure 10.

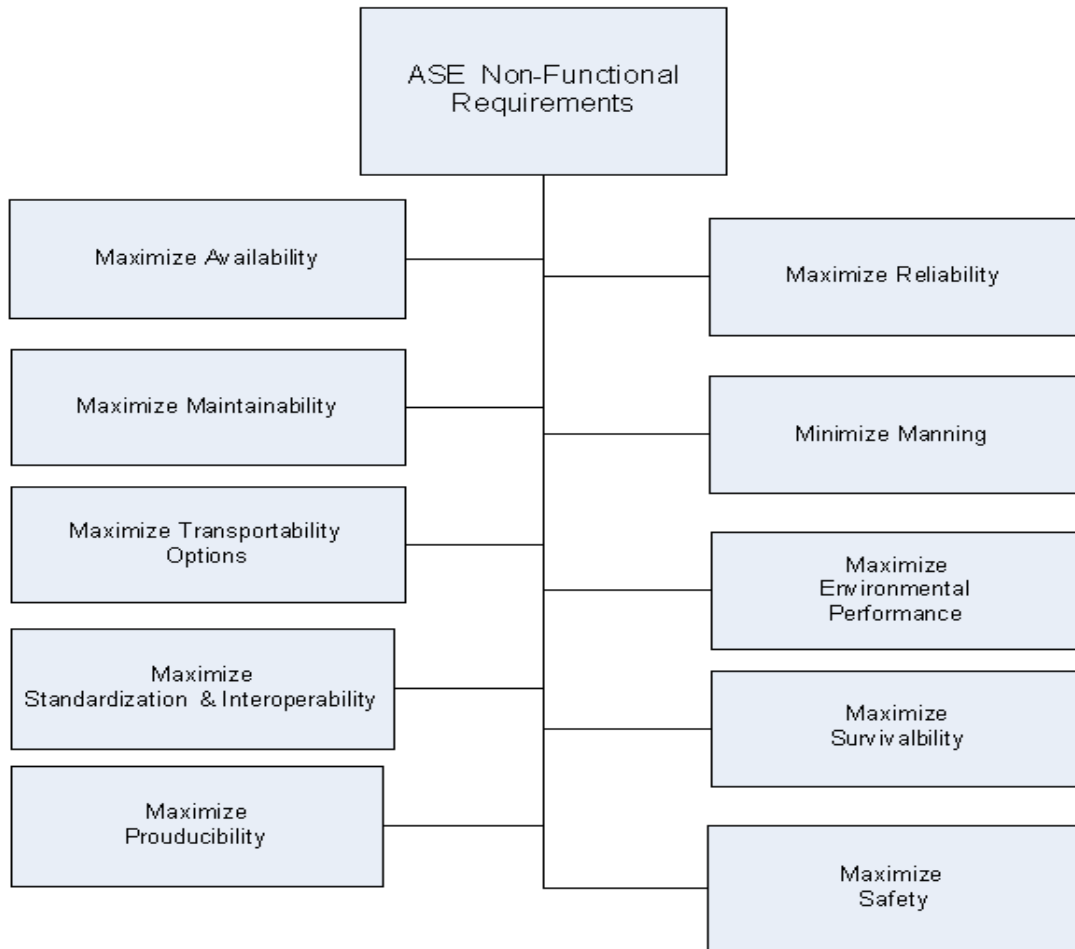


Figure 10. Non-Functional Requirements

While functional requirements frequently get the most attention, non-functional requirements are frequently extremely important to achieving a usable system and should be carefully considered during the systems engineering effort. Figure 10 identifies the ASE non-functional requirements. As stated above, for the purposes of this project the team did not do in depth analysis of non-functional requirements but a brief discussion of their relevance for an ASE system is presented.

Within DOD, three of the most commonly recognized non-functional requirements are Reliability, Availability and Maintainability (RAM) (OSD, 2009). An ASE that breaks down or has degraded performance frequently, or that is not available when needed or that has excessive maintenance costs is not a good solution. Manning levels are a major cost driver for ships and most new ship programs give consideration to minimizing or optimizing manning levels. Transportability is an important factor in system design when considering the total force and

logistics impact of a system. Will a system self-deploy and if so, under what conditions? If it cannot self-deploy, how will it be transported to its required destination? A system that requires special transportation equipment or procedures is not as attractive as one that can use existing transportation infrastructure.

The definition of environment in today's military structure has two independent meanings. The first is how the environment impacts a ship, and second is how a ship impacts the environment. As part of the non-functional requirements, both are considered. First is the function of the system as it operates in the environment; how will it operate in varying temperatures, winds, seas, climates, and beach topographies. The second is how the ship impacts the environment. This is a subject that continues to get significant press and the Navy faces increasing challenges regarding environmental compliance. An example is the use of sonar systems near sea mammals. Dumping of wastes and inadvertent transport of living organisms to foreign habitats are examples of other issues. The environmental requirements for a platform, including policies, should be considered during the systems engineering process. Standards, interoperability and open architectures can have a major impact on the life-cycles costs of a system as well as the system's ability to serve its primary functions. The ASE will have to interoperate with many other systems such as the systems that make up the sea base, port systems, and many others.

Survivability is a major consideration for any military platform. While specific aspects of survivability may be functional in nature (chaff launchers, armor, etc.), survivability as a whole can be considered a non-functional requirement. Since a military platform is expected to face adverse conditions, survivability should certainly be a factor in deciding on a final solution.

A system that is extremely expensive to produce will be less attractive than one that is not expensive to produce. Producibility of a design should be considered as one factor when faced with options on how to implement a solution.

The federal government and DOD have extensive rules regarding safety. The Operational Safety and Health Administration (OSHA) provides regulations and guidance related to federal employee safety, including MIL-STD-882D (Standard Practice for System Safety). While any military vessel or personnel will obviously face potential safety challenges due to the nature of

their missions, unnecessary safety risks are obviously undesirable and should be mitigated as much as possible during the systems engineering process.

The above is not a comprehensive list of non-functional requirements but represents some of the factors that should be considered in making a final selection of an ASE alternative. As mentioned above, the team did not have time for detailed analysis of these factors so this is left as an exercise for future projects.

## **H. VALUE SYSTEM DESIGN**

Sage and Armstrong state that the value system design is “probably the most controversial and crucial step of the entire [systems engineering] process” (Sage and Armstrong, 2000). To develop a value system the systems engineers, through interaction with the stakeholders, define objectives and organize them in relationship to one another, generally in a hierarchical tree such that lower level objectives feed a higher level. The functional hierarchy represents a piece of a potential ASE value system as it provides the hierarchical tree of functional/performance objectives. A complete value system contains many types of objectives, examples of which would include cost, quality, non-functional requirements and others. In addition to structuring the system objectives into a hierarchy, metrics or objective measures are assigned to the lowest level objectives in the objectives tree. These criteria are used for measuring the success of various alternatives at meeting the objectives that represent the requirements for the system. The result of value system design is a hierarchical organization of objectives with associated measures.

The team had significant interaction with some major stakeholders as described in the Stakeholder Analysis section. The majority of discussions and effort focused on needs for an ASE. The associated performance requirements are broadly represented by the functional hierarchy. The team expanded the functional hierarchy into an objectives hierarchy by adding potential metrics to the tree for the lowest level functions considered as shown in Figures 11 and 12. Due to the iterative nature of the systems engineering process, the metrics essentially converged with the requirements parameters over the course of analysis. The explanations for these metrics are included with the requirements descriptions provided in Section E (Requirements Analysis) of this report. The metrics in these figures represented the starting point for parameters selected for decision analysis.

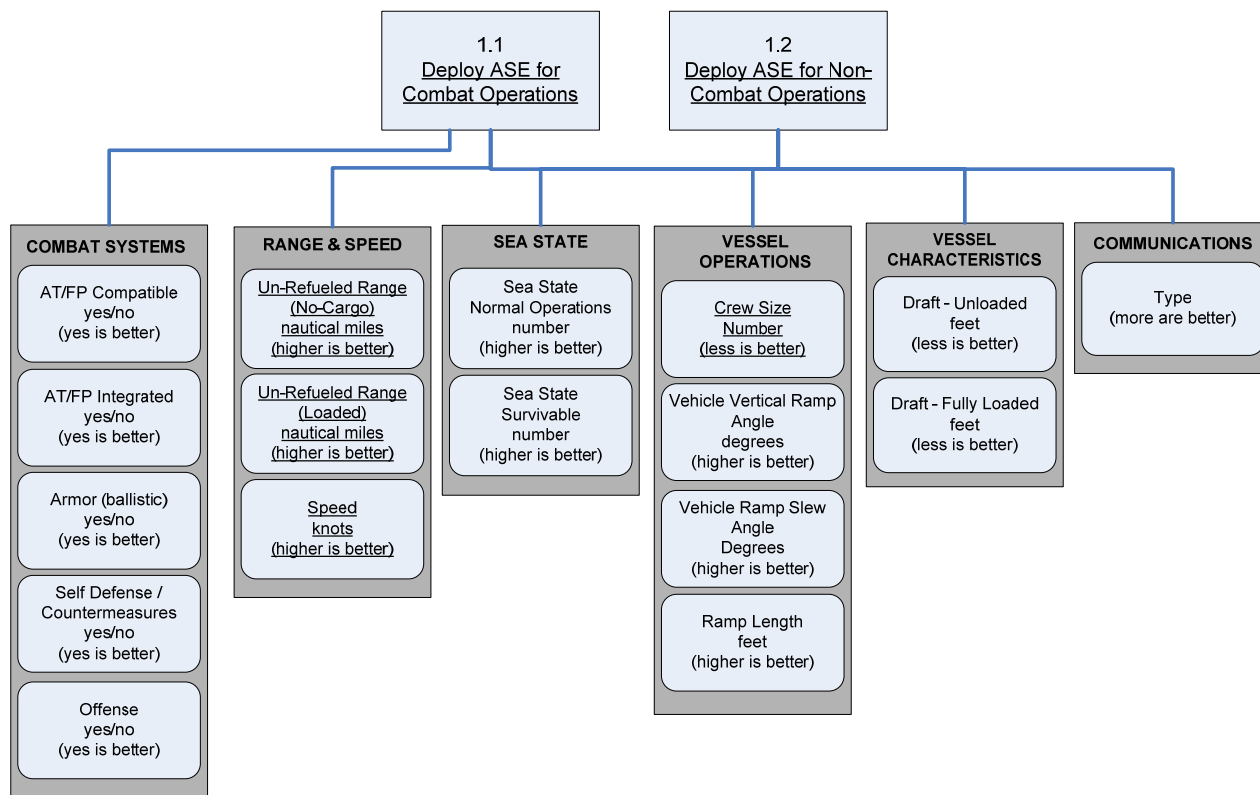


Figure 11. Objectives Hierarchy – Deploy ASE

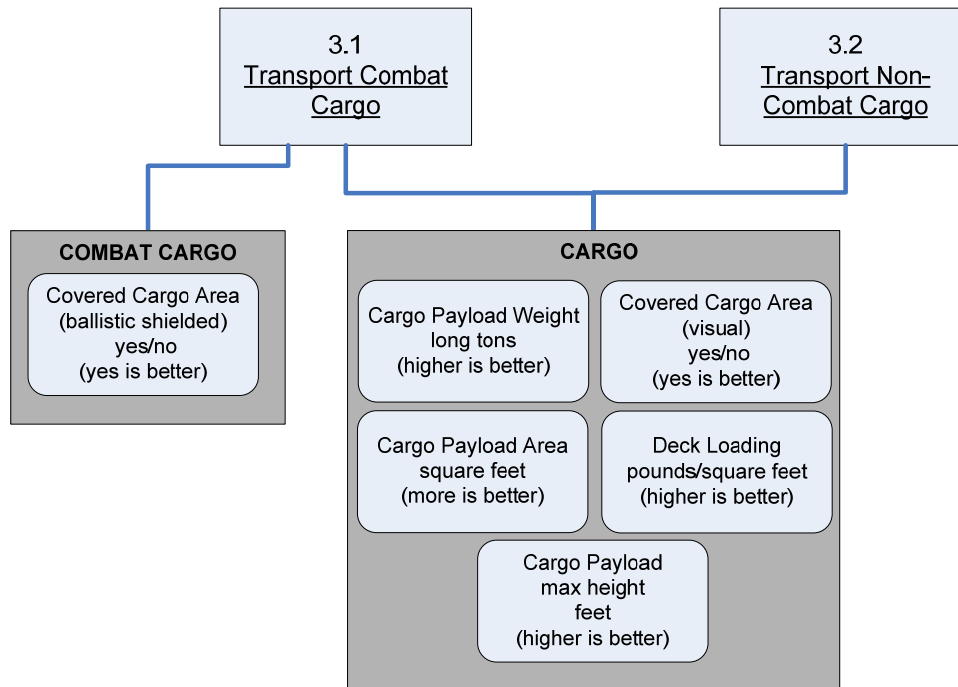
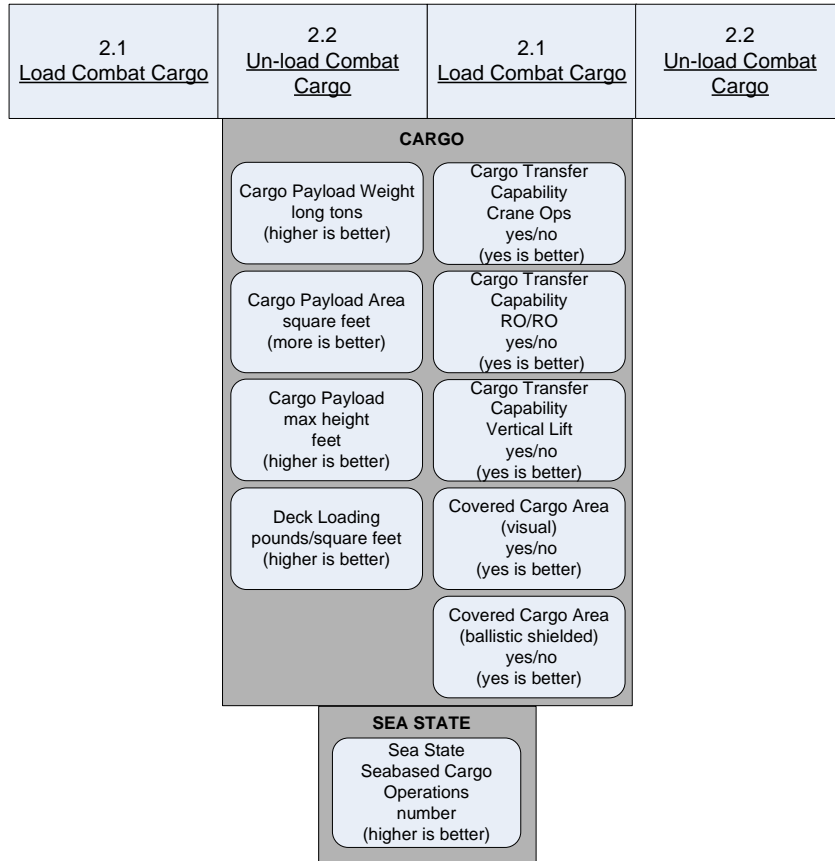


Figure 12. Objectives Hierarchy – Load/Un-load and Transport

Table 3 aligns the objective hierarchy metrics in Figures 11 and 12 with the critical technical parameters in Table 11 that were used for decision analysis. Table 3 also lists the metrics not used in this report but that are recommended for use in future research.

Table 3. Objectives Hierarchy Metrics – Critical Technical Parameter Alignment

Category	Objectives Hierarchy Metric (Figures 11 and 12)	Critical Technical Parameter (Table 10)	Future Research
Range & Speed	Un-Refueled Range (no cargo) (nautical miles)	Self-Deployment Range	
	Un-Refueled Range (loaded) (nautical miles)	Intra-Theater Range	
	Speed (knots)	Speed	
Sea State	Sea State (normal operations) (number)		Yes
	Sea State (survivable) (number)		Yes
	Sea State cargo operations (number)		Yes
Services	Quantity of Berthing (number)		Yes
Communications	Types (number)		Yes
Vessel Operations	Crew Size (number)	Crew Size	
	Vehicle Vertical Ramp Angle (degrees)		Yes
	Vehicle Ramp Slew Angle (degrees)		Yes
	Ramp Length (feet)		Yes
Vessel Characteristics	Draft (un-loaded) (feet)		Yes
	Draft (fully loaded) (feet)		Yes
Combat Systems	AT/FP Compatible (yes/no)		Yes
	AT/FP Integrated (yes/no)		Yes
	Armor (ballistic) (yes/no)		Yes
	Self Defense/Countermeasure Types (number)		Yes
	Offensive Capability Types (number)		Yes
Cargo	Cargo Payload Weight (short tons)	Cargo Capacity	
	Cargo Payload Area (square feet)		Yes

Category	Objectives Hierarchy Metric (Figures 11 and 12)	Critical Technical Parameter (Table 10)	Future Research
	Cargo Payload Max. Height (feet)		Yes
	Deck Loading (pounds/square foot)		Yes
	Cargo Transfer Capability Crane Ops (yes/no)		Yes
	Cargo Transfer Capability RO/RO (yes/no)		Yes
	Cargo Transfer Capability Vertical Lift (yes/no)		Yes
	Covered Cargo Area - visual (yes/no)		Yes
	Covered Cargo Area - ballistic shielded (yes/no)		Yes
Terrain	Beachable/Beach Un-load (yes/no)	Beachability	
	Clearance for Land Ops (feet)		Yes
	Land Grade (degrees)		Yes

## **I. ALTERNATIVES**

This section describes the material and non-material alternatives.

### **1. Non-materiel solutions and impacts**

Non-materiel solutions are methods of satisfying an identified need by changing something within the current operational infrastructure that does not entail a full-scale development or acquisition process. These solutions often involve process changes to increase efficiency or effectiveness of particular activities, training to improve performance with existing systems, or changes in policies that affect the procedures used to manage. Many of these non-materiel solutions may be accomplished in conjunction with other government agencies or through international coordination.

Often a team would consider non-materiel solutions before starting a project to develop or procure a new materiel solution. However, that level of analysis is beyond the scope of this effort. The ASE team will consider a variety of alternatives that may be suitable for the ASE role, some of them being existing platforms that need no additional development. In addition, the team considered non-materiel aspects of a total ASE solution such as non-functional system attributes and elements of the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) approach.

In this section DOTMLPF elements are briefly considered in terms of how those elements might impact an ASE solution or how the existence of an ASE capability might impact the DOTMLPF elements.

#### **a. Doctrine**

There are numerous doctrinal elements that could impact the requirements for an ASE. The most notable area of doctrine relates to seabasing doctrine. The team utilized many seabasing references in analyzing the requirements for an ASE. These source documents essentially represent the seabasing doctrine and directly impact the need for an ASE and how an ASE would be operated. As mentioned previously, the team made the assumption that seabasing was a desirable capability and essentially accepted the seabasing doctrine as presented in the sources reviewed. If the doctrines used for this project were invalidated or changed then there would obviously be a significant impact of the requirements for an ASE.

**b. Organization**

Organization of the Naval forces obviously impacts the requirements of an ASE. One example is the composition of a Marine Expeditionary Brigade (MEB). It is expected that ASEs will support the transportation of the MEB during major combat operations. Another example is how the elements of a sea base are organized. As part of the naval inventory, ASEs will have to be assigned to specific operational elements. The organization of naval logistic assets and bases will impact how ASEs are based and deployed. Support element organization could also be impacted as ASE systems will need to be maintained.

**c. Training**

Training is a ubiquitous requirement across the naval enterprise. Obviously, a new asset or an asset being used in a new capacity, such as the ASE, will have an impact on training requirements for naval personnel. The crew of an ASE would need appropriate training in operating the vessel and performing the tasks required to support ASE operations. The education and training acquired by individual personnel and the unit's training background are non materiel resources that contribute to the unit's capability. These resources are perishable and so continuing education and sustainment training must be part of the operational capability.

**d. Leadership and Education**

If an ASE ends up being a new capability then naval leadership will have to understand the impact of this new asset on mission operations and capabilities. The most significant aspect is most likely the enabling of seabasing and its impact on the nation's ability to project power. Leadership will need to be educated on the new capabilities and their potential and impact.

**e. Personnel**

ASE personnel resource requirements involve not only having the right number of people ready and available, but also having the right occupational specialties for each job description. While an ASE might be a new capability it is unlikely to have significant personnel impacts from a naval enterprise perspective.

**f. Facilities**

Facilities will be required to support docking and maintenance of an ASE, as with any other platform, however, it is unlikely that any new facilities would be required as there are no unique aspects identified related to an ASE platform that would require special facilities.

## **2. Materiel Solutions**

The final piece of the DOTMLPF lexicon is the need for a materiel solution. As part of the analysis, the team analyzed seven different alternatives. Each of these alternatives is discussed below. Each alternative description contains a table of its primary characteristics including key parameters upon which the decision analysis was conducted.

### **a. Ship to Shore Connector (SSC)**

The Ship to Shore Connector (SSC) is an Air Cushion Vehicle (ACV) currently in the contract design phase. The SSC (Figure 13) is slated to replace the current Landing Craft Air Cushion (LCAC) craft with an Initial Operational Capability (IOC) in FY2019 (Carlson, 2009).

While the SSC is a replacement for the current LCACs, it will provide increased operational capabilities with a significant improvement in the craft's reliability. The SSC characteristics are listed in Table 4.

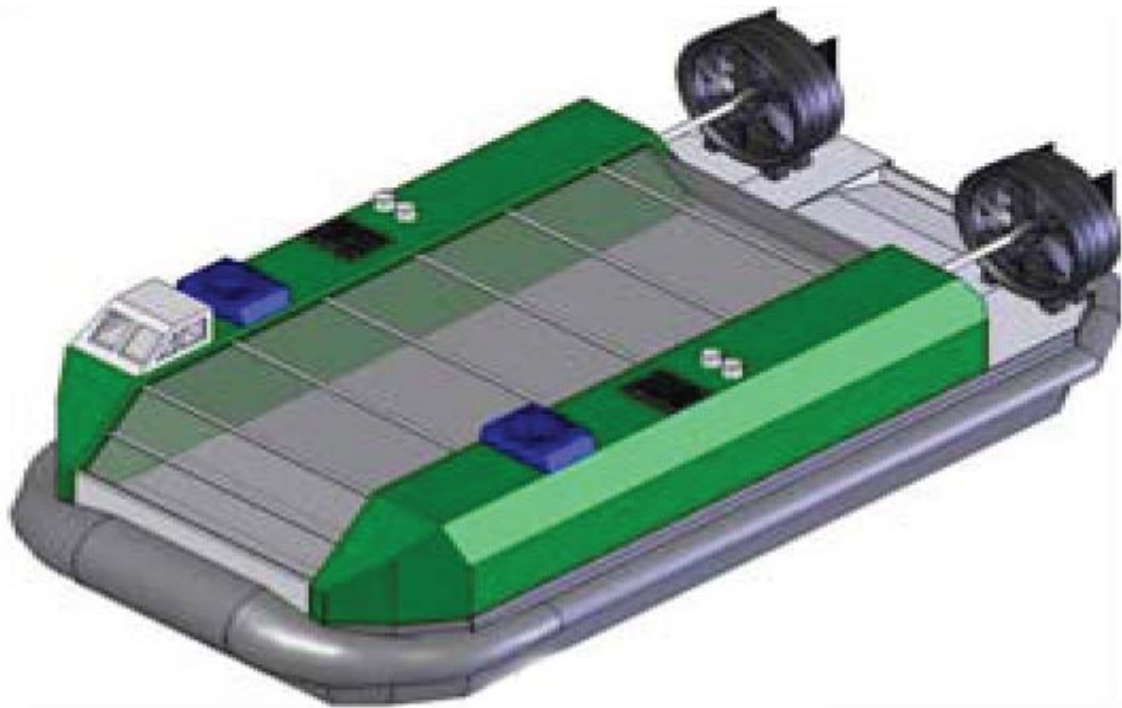


Figure 13. Ship To Shore Connector (SSC) (Artist's concept)

Image from: (Carlson, 2009)

Table 4. SSC characteristics

Length Over All	93.2 feet (28.4 meters)
Beam (Width)	48.1 feet (14.66 meters)
Range (self-deploy)	86 nautical miles
Speed (loaded)	40 knots
Cargo Capacity	75 short tons (67long tons)
Crew Size	5
Beachable	Yes

**b. T-Craft**

The T-Craft (for Transformable Craft) is being developed under an Office of Naval Research (ONR) project on advanced sea base enablers. The objective of the T-Craft project is to provide “game changing” capabilities that will support making the Sea Power 21 vision of seabasing a reality. At the time of this report the T-Craft project is completing phase 1 under which three contractors with competing designs are developing T-Craft concepts. ONR’s objective is to move the project to phase 2 under which one contractor will be selected to develop a prototype system for testing. Figure 14 depicts one of the T-Craft’s concept designs.

This project makes no judgment as to the engineering or naval architecture feasibility of the various T-Craft concepts.

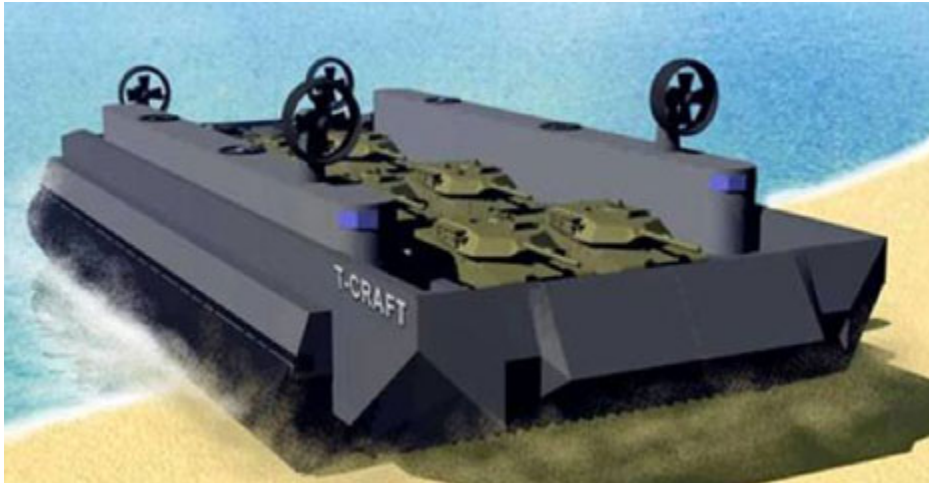


Figure 14. T-Craft (artists concept)  
 Image from <http://www.marinelog.com/IMAGESMMVII/tcraft.jpg>

Key aspects of the ONR Broad Agency Announcement (BAA) for the T-Craft are that the T-Craft will be able to:

- Travel 2,500 nautical miles at 20 knots in sea state 5
- Transfer Cargo (tanks, equipment, personnel, etc.) from the sea base to the T-Craft at sea in state 4 seas
- Traverse a 250 nautical miles Radius of Action in sea state 4 conditions at 40 knots
- Deliver 300 LT of Cargo to a dry Beach with a 0.5-2.0% (0.3-1.1 degree) slope
- Drive off of the Beach and return 250 nautical miles to the sea base at 40 knots in sea state 4 without re-refueling

The T-Craft concepts being created independently by Alion, Umoe Mandel and Textron are a merging of three ship-type concepts; the catamaran, the surface effect ship and the air cushion vehicle. Table 5 lists the T-Craft characteristics. A catamaran utilizes two hulls that uses hydrostatic lift to support the hulls that are long and slender which, from a hydrodynamic point of view, are good shapes for high speed and operation in higher sea states, and is propelled with in-water propulsors. A surface effect ship (SES) also has two long and slender hulls with fabric seals or skirts at its bow and stern. It can operate as a catamaran at very low efficiency or in the

design configuration with lift fans that are driven to put air under the main hull to create the air cushion. The SES then is raised well out of the water by the air cushion minimizing the frictional wetting of the twin hulls or sidewalls which enables the SES to achieve very high speeds and with a ride control system. It has an improved ride quality and is propelled with in-water propulsors. An air cushion vehicle (ACV) rides on a cushion of air which is contained by fabric seals or skirts around its entire periphery. An ACV uses lift fans to provide its cushion air, is amphibious, and is powered by air propellers; hence, it has limited range and speed. (Wilson, 2009).

The vision for the T-Craft is that it will be an SES which can operate at times as a catamaran or as a standard SES but at various lift system power setting, thus varying the amount of sidewall depth in the water. When operating as an ACV, the skirts are released from the sides of the hull and mating with the bow and stern seals such that the entire lower periphery of the vessel is covered by the skirts.

This combination of modes will provide capabilities for self-deployment at significant ranges, high speed transfer of cargo from the sea-base to the destination, and amphibious delivery of the cargo and personnel “feet dry” to a beach. The T-Craft will also be required to interface to sea base assets and support other required naval vessel and military requirements such as limited self-defense and Command, Control, Communications, Computers, Intelligence (C4I).

Table 5. T-Craft Characteristics

Length Over All	Nominally 240 feet (73.2 meters)
Beam (Width)	Nominally 70 feet (21.3 meters) catamaran / 100 feet (30.5 meters) ACV
Range (self-deploy)	2500 nautical miles
Speed (loaded)	40 knots
Cargo Capacity	336 short tons (300 long tons)
Crew Size	3
Beachable	Yes

Source: (Wilson, 2008)

**c. Landing Craft Air Cushion (LCAC)**

The Landing Craft Air Cushion (LCAC) is a fully amphibious ACV craft that utilizes an air cushion to “lift” the craft out of the water and supports the craft and its entire payload. It is able to carry 60 short tons (75 overloaded) at speeds up to 40+ knots. Table 6 lists the LCAC characteristics.

LCAC’s, as shown in Figure 15, first achieved Initial Operational Capability (IOC) in 1986. At that time they were intend to have a service life of 20 years. Beginning in 2000, the class began to undergo a Service Life Extension Program (SLEP) that will extend the operational life to 30 years. The SLEP LCAC’s will be used to bridge the availability gap until the Ship to Shore Connectors (SSC)’s come on line.



Figure 15. Landing Craft Air Cushion (LCAC)  
Image retrieved from <http://www.fas.org/man//DOD-101/sys/ship/lcac-50-1.jpg>

Table 6. LCAC Characteristics

Length Over All	87 feet, 11in (26.8 meter) -on cushion
Beam (width)	47 feet (14.3 meter) - on cushion
Range (self-deploy)	200 nautical miles
Speed (loaded)	40 knots
Cargo Capacity	60 short tons (53 long tons) 75 short tons (67 long tons) - overload
Crew Size	5
Beachable	Yes

Source: (Marine Corps, 2001)

**d. Joint High Speed Vessel (JHSV)**

The Joint High Speed Vessel (JHSV) program is a Navy led acquisition to procure a high-speed, shallow draft ship capable of intra-theater transport of personnel and cargo for the joint force. The JHSV, as shown in Figure 16, is being designed to be capable of transporting 700 short tons of troops, supplies, and equipment 1200 nautical miles at an average speed of 35 knots in a significant wave height of 1.25 meters – sea state 3.



Figure 16. Joint High Speed Vessel (JHSV)  
Image retrieved from (Austal JHSV Team, 2009)

The JHSV is intended to fill the gap between low-speed sea lift and high speed airlift by transporting personnel, equipment, and supplies over operational distances. The JHSV will have a shallow draft and high speed to allow for fast transit and access to austere and degraded ports. The JHSV will be designed to allow for immediate offload of combat-ready troops and equipment. JHSV will have the ability to self-deploy directly to the sea base or to the operational area. The JHSV will operate under the protection of other vessels and will only operate independently in permissive/benign environments. The JHSV does not have the ability to deliver cargo or personnel directly to an unimproved beach without additional resources.

Table 7. JHSV Characteristics


Length Over All	337.9 feet (103 meters)
Beam (width)	93.5 feet (28.5 meters)
Range (self-deploy)	5600 nautical miles
Speed (loaded)	35 knots
Cargo Capacity	700 short tons (625 long tons)
Crew Size	41
Beachable	No

Source: from (Austal JHSV Team, 2009)

The JHSV will not be a forcible entry asset and will be designed to commercial shipbuilding standards. The first JHSV is currently scheduled to be delivered in the beginning of FY12 with the remaining ships being delivered starting in FY13.

Table 7 lists the JHSV characteristics and Figure 16 shows the general design of the JHSV following the Phase I contract period. The JHSV program is currently in phase II, detailed design and construction. Construction of the first JHSV is scheduled to begin in November 2009. As Greg Trauthwein noted “Austal is the prime contractor for the project and the company will design and construct the first 103-m JHSV with options for nine additional vessel - a program worth a potential \$1.6B – expected to be exercised between FY09 and FY13” (Trauthwein, 2009).

GENERAL VESSEL DESCRIPTION	
Vessel Type	Joint High Speed Vessel
Material	Aluminium
Hull Form	Round bilge, bulbous bow, catamaran
PRINCIPAL DIMENSIONS	
Length	103.0m (337.9 ft)
Beam	28.5m (93.5 ft)
Draft	3.83m (12.57 ft)
MISSION BAY	
Area (with Tie-Downs)	1,863m <sup>2</sup> (20,053 ft <sup>2</sup> )
Clear Height	4.75m (15.6 ft)
Turning Diameter	26.2m (86.0 ft)
ISO TEU Stations	6 Interface Panels
ACCOMMODATIONS	
Crew	41
Single SR	2
Double SR	6
Quad SR	7
Troop Seats	312
Troop Berths	
Permanent	104
Temporary	46
Galley & Messing	48
PROPULSION	
Main Engines	4 x MTU 20V8000 M71L Diesel Engines
	4 x 9.1 MW
Gear Boxes	4 x ZF 60000NR2H Reduction Gears
Waterjets	4 x Wartsila WLD 1400 SR
PERFORMANCE	
Speed	
Average	35 knots @ 90% MCR with 635 mt (700 st) payload
Maximum	43 knots without payload
Range	
Maximum Transit	1200 nm
Self-Deployment	5600 nm
Survival Through	SS-7



AVIATION FACILITIES	
NAVAIR Level 1 Class 2 Certified Flight Deck for one helicopter	
Centerline parking area for one helicopter	
NAVAIR Level 1 class 4 Type 2 Certified VERTREP	
Helicopter Control Station	
AUXILIARY SYSTEMS	
Active Ride Control	
Transcom Interceptors	
Folls: 3.24 m <sup>2</sup> (34.9 ft <sup>2</sup> ) each, forward on Inboard sides of demi-hulls	
Vehicle Ramp	
Articulated Slewing Stern Ramp	
Straight aft to 45° Starboard	
Telescoping Boom Crane	
12.3 mt @ 15m, 18.2 mt @ 10m	
(13.6 Lt @ 49.2 ft, 20.1 Lt @ 32.8 ft)	




Figure 17. Joint High Speed Vessel (JHSV) General Vessel Description

Image retrieved from (Austal JHSV Team, 2009)

**e. Logistics Support Vessel (LSV)**

The Logistics Support Vessel (LSV), shown in Figure 18, is a self deployable vessel that provides transport of vehicles and cargo. The LSV can perform intra-theater supply of cargo and equipment. The LSV has both bow and stern ramps. The LSV is ideally suited for Roll-on/Roll-off (RO/RO), Large, Medium-Speed, RO/RO Ships (LMSR) and Logistics Over-the-Shore (LOTS) operations. The LSV can perform tactical re-supply in remote areas with unimproved beaches as well as austere ports. The LSV has a bow thruster to assist with beaching, beach extraction, docking, undocking and can conduct these operations without landing.

The first LSV will begin to reach the end of its projected lifecycle in 2013. The LSV has been identified by the Army for modernization and service life extension beginning in 2009 to extend the useful life until 2024. The modernization program is planned to be complete before 2015. The modernization strategy includes the equipping of LSV's with updated C4ISR and AT/FP capabilities. The LSV's lack of speed will remain an issue after modernization.



Figure 18. Logistics Support Vessel (LSV)  
(Army, 2008)

The LSV has an un-refueled range with No-Cargo of 8,200 nautical miles at 12.3 knots and an un-refueled range loaded is 6,500 nautical miles at 11.5 knots. The LSV can perform sea based cargo operation at sea state 3. The LSV can beach, but cannot operate over land. The LSV requires a crew of 32. Table 8 lists the LSV characteristics.

The LSV has a cargo payload capacity of 2000 short tons. The LSV deck area of 10,500 square feet and can accommodate 24 M1 main battle tanks. Cargo can be transferred via crane

operations and RO/RO. The LSV does not have vertical lift capabilities. The LSV has a ramp length of 32 feet.

The LSV is currently deployed as part of the Army watercraft fleet and is part of the U.S. Army plan for supporting a sea base as shown in Figure 19.

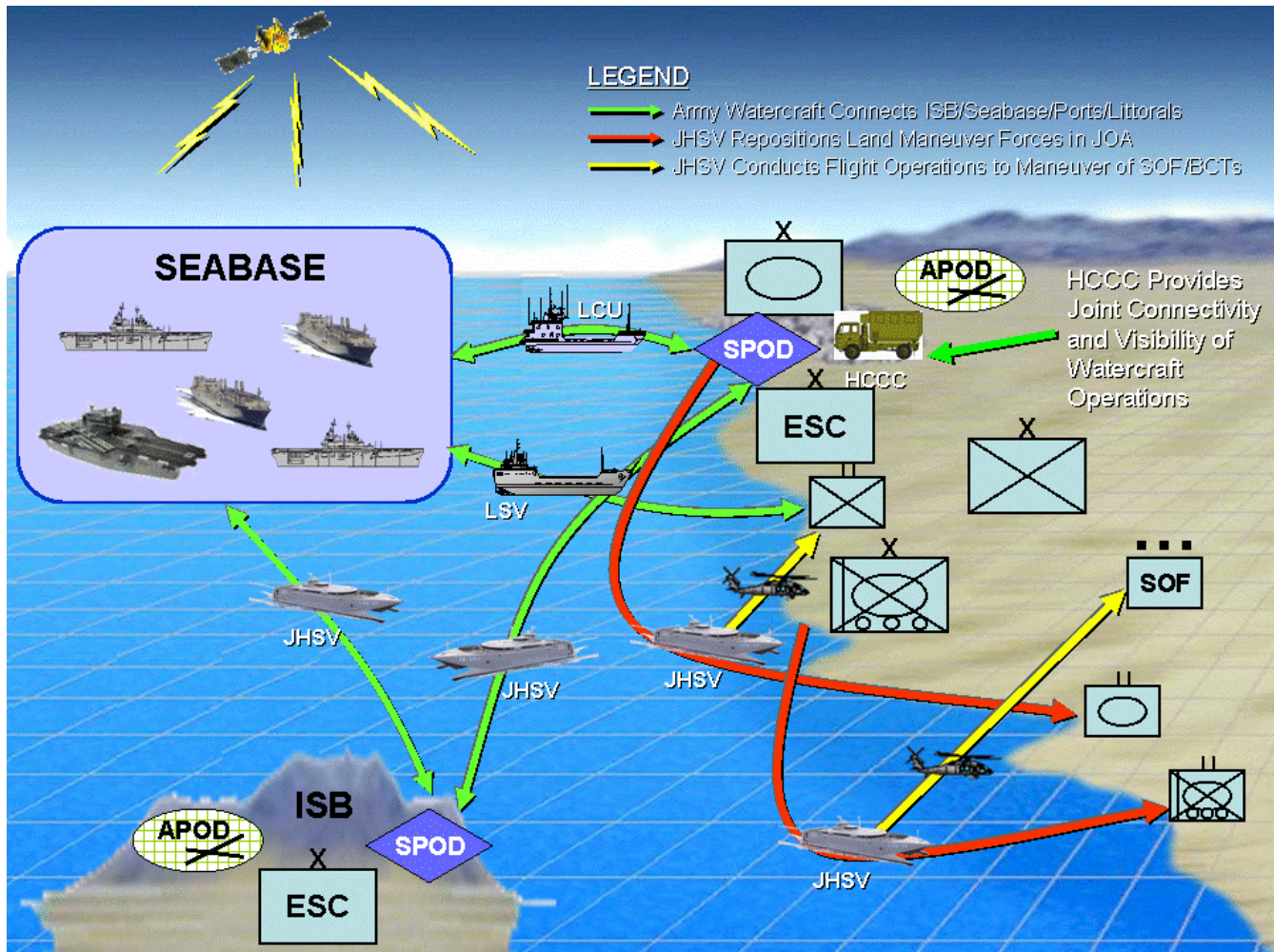


Figure 19. LSV as sea base Connector  
Image from: (Army, 2008)

The LSV can self deploy from CONUS to the sea base location. At the sea base location it is loaded via crane or RO/RO as needed and provides the sea base connector function to port facilities or directly to the beach.

Table 8. LSV Characteristics

Length Over All	273 feet (83.2 meters) - LSV1-6 314 feet (95.7 meters) - LSV7-8
Beam (width)	60 feet (18.3 meters)
Range (self-deploy)	8,200 nautical miles
Speed (loaded)	11.5 knots
Cargo Capacity	2,000 short tons (1785 long tons)
Crew Size	32
Beachable	Yes

**f. LCU - 2000**

The Landing Craft, Utility 2000 (LCU) provides transport of combat vehicles and cargo. Re-supply missions can be undertaken to remote areas with austere shore facilities and unimproved beaches. The LCU, shown in Figure 20, is ideally suited for the discharge or loading of sealift including RO/RO such as with Military Sealift Command's large, medium-speed, roll-on/roll-off ship (LMSR) and Logistics Over-the-Shore (LOTS) operations. The LCU has a bow ramp for RO/RO cargo and a bow thruster to assist in beaching, beach extraction, docking, undocking and is able to perform these operations unassisted.

The LCU will begin to reach the end of its projected lifecycle in 2015. The LCU has been identified by the Army for modernization and service life extension beginning in 2012 to extend the useful life until 2024. The modernization program is planned to be complete before 2015. The modernization strategy includes the equipping of LCU's with updated C4ISR and AT/FP capabilities. The LCU's lack of speed, similar to the LSV, will also remain an issue after modernization.



Figure 20. Landing Craft Utility: LCU-2000  
Image from: (Army, 2008)

The LCU has an un-refueled range un-loaded of 9,200 nautical miles at 12 knots and an un-refueled range loaded of 6,500 nautical miles at 10 knots. The LCU can perform sea based cargo operations at sea state 3. The LCU can beach, but cannot operate over land. The cargo payload capacity is 350 short tons. The deck area of 2,500 square feet and can accommodate 5 M1 main battle tanks. Cargo can be transferred via crane operations and RO/RO. The LCU does not have vertical lift capabilities. The LCU has a ramp length of 22 feet. The LCU requires a crew of 13. The LCU characteristics are listed in table 9.

The LSU is currently deployed as part of the Army Water Craft fleet and is part of the U.S. Army plan for supporting a sea base as shown in Figure 19. The LCU can self deploy from CONUS to the sea base location. At the sea base location it is loaded via crane or RO/RO as needed and provides the sea base connector function to port facilities or directly to the beach.

Table 9. LCU-2000 Characteristics

Length Over All	174 feet (53.04 meters)
Beam (width)	42 feet (12.8 meters)
Range (self-deploy)	9,200 nautical miles
Speed (loaded)	10 knots
Cargo Capacity	350 short tons (312 long tons)
Crew Size	13
Beachable	Yes

**g. Airlift**

The ability to re-supply combat forces over long distances without depending on truck convoys is fundamental to the operational concepts of sea-basing. This means that Marine Corps ground forces and early-entry Army forces will be more dependent on air transport than they ever have been in the past, as shown in Figure 21.

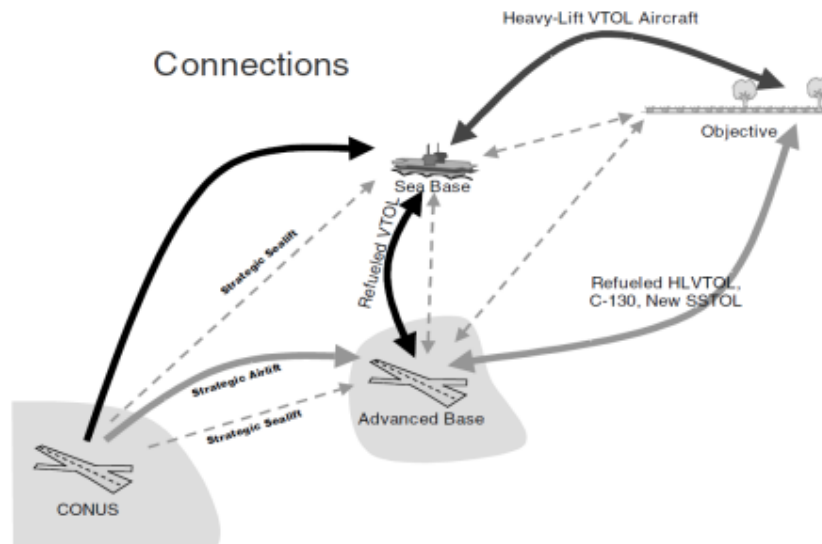


Figure 21.

Notional sea base airlift

Image from: (NRC, 2005)

The capability to project influence from the sea base to a forward objective is not strictly limited to surface operations. The ability to employ airlift provides the regional commander with flexibility of maneuver across multiple mission scenarios in conjunction with surface operations or acting independently. Prior to 2007 there were two distinct programs within the DOD that sought to define, test, and equip future forces with the next generation airlift vehicle.

Joint Heavy Lift (JHL) was a program under direction of the US Army that sought primarily vertical take-off and landing (VTOL) configured aircraft for the next generation airlift mission. JHL requirements were built around transporting the future combat system (FCS) 20 ton combat vehicles directly to the objective for Lightning strike capability. In May 2007, the Army picked the Quad Tilt-rotor (Figure 22), an 80-ton behemoth nearly the length of a C-130. Designed by a Bell-Boeing Textron team, the four-rotor aircraft was intended to carry 10 tons of fuel and 20 tons of cargo up to 4,000 feet at temperatures up to 95 degrees Fahrenheit (Osborn, 2008). The VTOL capability of this aircraft allows the strike force to go directly to an objective a significant distance inland over almost any terrain as opposed to a beachable water-borne vessel or amphibious vessel which requires an intermediate stop and staging point.



Figure 22. Bell/Boeing Quad Tilt-rotor concept  
Image from: (Sklar, 2006)

Due to a significant paradigm shift in combat operations, due in part to the evolution of the IED (improvised explosive device), the manned FCS vehicles are required to be equipped with much more armor. The revised armor requirement has increased the transport weight of many of these vehicles to a range of 25-30 tons (Grant, 2008). This revised weight requirement invalidates previous design configurations – namely the Quad Tilt Rotor.

Since 2005, the Air Force had been working on a future-airlift program of its own, the Advanced Joint Air Combat System (AJACS). Early design models from the Air Force Research Laboratory, headquartered at Wright-Patterson Air Force Base, Ohio, show a tougher, stealthier, slightly larger C-130-type cargo plane. The aircraft will have short-takeoff and landing ability (STOL), which is generally defined as being able to take off and clear a 50-foot high obstacle at the end of a 2,000-foot runway. The plane will have a top speed comparable to that of a commercial airline: Mach 0.8, about twice as fast as the C-130. (Osborn, 2008) As shown in Figure 23, Boeing, Lockheed and Northrop Grumman have been involved in AJACS development.



Figure 23. Concepts for future STOL airlift

(L to R Lockheed MACK vehicle, Northrop concept, Boeing modified C-17)

Image from: <http://www.defenseindustrydaily.com/ajacs-load-us-begins-another-nextgen-tactical-transport-project-03230/>

The capabilities of both platforms types will impact the future mission configuration of the sea base. Recently the two programs have been brought under one developmental umbrella and the effort has been re-designated Joint Future Theater Lift (JTFL) (Osborn, 2008). The Defense Science Board study published in July 2007 stated:

Distance, volume, weight, and speed requirements – as well as likely threat environments rule out ground transportation in many instances. Deployed forces will require air bridges connecting enclaves to more developed intermediate supply bases (ISBs) or sea bases far from the scene of combat. The single best fit for a tactical ground combat support aircraft is one that combines elements of both rotary and fixed-wing technology in a hybrid aircraft. (Defense Science Board, 2007)

The change in program organization does not detract from the fact that a next generation mobility aircraft is needed to truly exploit all the benefits of seabasing. Figure 24 shows the payload delivery required (in tonnage vs. range) by airlift in order to sustain mission operations ashore. The configuration of the sea base's landing and loading platforms will be driven by this next generation mobility aircraft; so it is essential that the requirements and attributes of this

hybrid aircraft are well defined. A composite specification for this vehicle is detailed in Table 10.

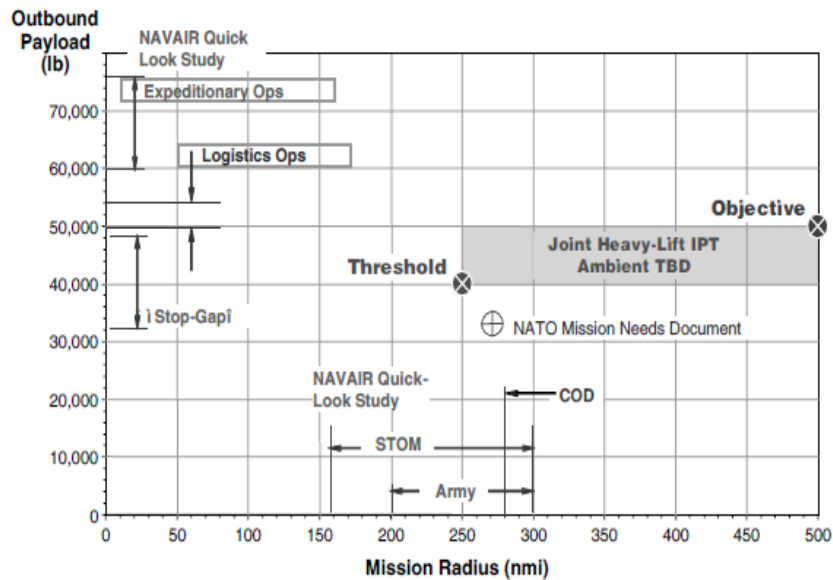


Figure 24. Airlift payload tonnage v. range  
Image from: (NRC, 2008)

Table 10. Next Generation Air Mobility Requirements

Attribute	Requirement
Payload	>30 short tons
Speed	>300 knots
Mission radius	250-500 nautical miles
Cargo space	Consistent with FCS vehicle spec
Transit altitude	>15000 ft
Take-off & landing	Capable of VTOL but able to use 1,000 feet runway
Joint operability	sea base compatible
Environment	Operate at 4000 feet with 95F temp

(Defense Science Board, 2007)

The ability to employ airlift as a seabasing enabler provides regional commanders superior flexibility in executing mission tasking. Airlift not only enables but accentuates the other logistics capabilities such as water and land based connectors by delivering key mission components either to the beach, port, or even further inland to allow for sustainment and security.

## IV ANALYSIS

During the analysis phase of the systems engineering process the team brought together previously developed and defined alternatives and needs. The team examined the potential of the seven alternatives (defined in the formulation section) to determine how they met the requirements identified by earlier steps. This evaluation also determined any “impacts or consequences of the alternatives” applicable to any issues defined in the value system (Sage and Armstrong, 2000).

The team performed detailed research to assemble a list of key requirements that pertained to various operational scenarios, as detailed in Section I. This list was compiled and sent to the stakeholders in the form of a survey. The stakeholders were asked to rank the requirements from most desired to least desired utilizing a number scale as described in Section II (Formulation – Requirements Analysis). The results of these rankings were compiled and the six primary requirements for the ASE were determined, as seen in Table 11. These threshold and objective values were developed after extensive review on seabasing and interviews with the project stakeholders. For the two missions considered (MCO and Humanitarian), the threshold and objective values for these specific parameters were considered to be equal, with the exception of beachability as described later. During this phase of the project we were interested in the ability of the craft to conduct the mission, not necessarily the parameters of the mission and we did not include other parameters of the mission such as weather conditions (wind, sea state, temperature, humidity, etc) , time of day (or night) nor other potentially relevant parameters.

Value curves were generated based on this ranking data. The team used the Multi-Attribute Utility theory (MAUT) process to compare the strengths and weaknesses of each alternative with regard to the objectives. In addition, the team performed selective Modeling and Simulation (M&S) on the major combat operation scenario for one alternative, which appears to be most demanding scenario. Our limited simulation analysis serves as a platform for future researchers to conduct a more comprehensive M&S study, using any number of potential simulation tools.

Table 11. Critical Technical Parameters

Parameter	Threshold	Objective
Self-Deployment Range	1000 nautical miles	2500 nautical miles
Crew size	100	0
Intra-Theater Range	25 nautical miles	250 nautical miles
Speed	20 knots	40 knots
Cargo Capacity	300 short tons	600 short tons
Beachability	No	Yes

## A. FEASIBILITY SCREENING

Once the team generated a number of alternatives the next step in the process is to perform a feasibility screening based on certain criteria. The purpose of feasibility screening is to save analysis time by eliminating alternatives that are obviously not suitable for consideration before detailed analyses are performed. Based on research and stakeholder feedback, at this broad level of system design the only screening criteria defined was the ability of the ASE to beach for combat operations. As mentioned in the formulation section, beachability is being capable of delivering cargo and personnel directly to the beach without the need for any additional infrastructure. Beachability was a critical requirement for combat missions and desirable for humanitarian aid missions. As a result of the screening criteria, the JHSV was ruled out of the decision analysis for combat missions.

Due to the recent changes in focus regarding the future of joint airlift there is currently no cohesive vision regarding specific requirements, much less a flagship design that embodies the desired joint airlift capability. The team members collectively agreed that including dated joint airlift requirements into the ASE decision analysis would not add any merit to the analysis, therefore it was screened out. It is the professional collective opinion of the team that joint airlift should be included in any and all future ASE analysis, once the requirements are jointly vetted and the program has reach an appropriate level of technical maturity.

## B. MODELING, SIMULATION AND ANALYSIS

### 1. Modeling and Simulation Approach

#### a. Definition of the Objective

The desired objective of the analysis phase of our study was to determine which of the various alternative systems (or combinations thereof) is better in terms of the parameters

of interest established in Section II. Particularly, the processing and movement of cargo and forces ashore, as established in the objectives hierarchy, are the most significant parameters. While we discuss a broad analysis of the capabilities of each of the proposed alternative vessels in the next chapter, our M&S analysis is limited to one alternative technology, the LCAC, for which functional information exists. The M&S analysis therefore seeks to determine whether the LCAC alternative meets the threshold requirements of the value hierarchy. The major purpose for M&S in this simulation analysis is to lay the foundation for future work such as the development of functional architectures for the various alternatives.

Of the four mission areas described earlier (Major Combat Operation, Police Enforcement Operation, Natural Disaster Relief, and Humanitarian Aid), Major Combat Operation was chosen as the primary operational scenario for study. The primary reasons for this choice are the availability of applicable data and the relative importance of the mission scenario. The M&S analysis will focus on evaluating sections 2 and 3 of the objectives hierarchy, Load/Un-load Cargo and Transport Combat Cargo, respectively, in the context of the MCO scenario.

**b. Context of the Evaluated Objective**

The context focuses on the critical operational issue among stakeholders, which is ship-to-shore movement of equipment, supplies, and personnel, and is captured in sections 2 and 3 of the objectives hierarchy. The parameters of interest in this context are Cargo Payload Weight, Cargo Payload Area, Cargo Payload Maximum Height, Deck Loading, Cargo Transfer Capabilities, and Sea State

**c. M&S Requirements Analysis**

The analysis of system parameters performed with utility curves and static spreadsheet models does not capture the dynamic behavior of the alternative systems under study. Discrete-event simulation is a popular technique that can be employed in the study of dynamic systems, and is herewith employed as part of the analysis of alternatives. More specifically, a process-oriented discrete-event approach is used.

Three primary world views exist in discrete event simulation programming: the activity-oriented paradigm, the event-oriented paradigm, and the process-oriented paradigm (Matloff, 2008). Activity-oriented simulations step through time at small, uniform time increments and

check for state changes at each step. This approach is well suited for systems in which activity delays and inter-arrival times are continuous random variables, as is the case for the alternative systems herein, but is very slow to execute. Multiple experiment runs would require a significant amount of time to complete, and therefore the activity-oriented paradigm is deemed unsuitable for employment in this study.

The event-oriented paradigm is somewhat more desirable since it shortcuts the time-incremented approach of the activity-oriented method by storing a set of all pending events and proceeding from one stored event time to the next. The event-oriented process is more flexible, executes faster, and is easier to implement than the activity-oriented approach.

Lastly, the process-oriented approach is one in which simulation activities are modeled by processes. The uniqueness of this approach is found in the concurrent nature of the processes. The idea that concurrent processes exist is a natural one. Many processes execute independently of one another, but it is more often the case that processes are interdependent; their states being dependant on the states of other processes. The major benefit of this paradigm is the ability to more closely model a system as it would exist in nature. The process-oriented paradigm has all the benefits of the event-oriented paradigm, but also has the added benefit of natural representation. Therefore, the process-oriented method is the approach adopted for the purposes of this study.

#### **d. Selection of Synthetic Environment**

All of the aforementioned factors were evaluated in determining which simulation tool to adopt for use in this study. Initially, the study adopted an approach using the SimPy simulation software library since highly skilled M&S personnel with experience using this library were available. However, given that basis of future work concerning this topic will rely partly on the resulting models and data sets of this study, it has been determined that a need for ease of use is the most important factor. It is unlikely that future modelers will have the requisite knowledge and ability to quickly and easily utilize any work or product developed in a software library environment. Of equal importance is the choice of a tool that is popular and widely available. For these reasons, Extend<sup>TM</sup> is chosen as the preferred M&S simulation environment.

## **2. Model Constructs**

### **a. Description of Scenario and Mission**

The scope of the simulation study was limited to a major combat operation (MCO) scenario. Specifically, it was limited to those mission areas of MCO utilizing the ASE as a ship-to-shore connector. This mission role corresponds to the functions in the Objective Hierarchy: “2.0 Process Cargo” and “3.0 Transport Cargo”.

The intent of the simulation study was to capture the performance of this mission role with a functional system consisting of one LMSR, one MLP, and six LCAC craft. This functional configuration is herein referred to as the "baseline" configuration. This baseline was chosen because it utilized known systems. Seabasing consists of many platforms whose characteristics have not been adequately defined and tested, especially in relation to the Function 2.0 Process Cargo. For this reason, only the baseline case was explored.

The baseline MCO scenario was defined as a combat mission that needed to bring ashore notional combat equipment for one Marine Expeditionary Brigade (MEB) from a sea base located 25 nautical miles from the objective (beach). Large construction equipment that may be associated with a MEB is not included in the simulation because the size of the equipment does not permit transportation to the sea base via the LMSR and therefore cannot participate in the assembly process aboard the LMSR.

In the simulation, the LCAC craft are able to travel at maximum speed (40 knots), in an operating environment that consists of sea state 1 with an air temperature of 70 degrees F. Six LCAC were chosen for this simulation because it is the maximum number of LCAC that can be assigned to a ship per NWP 3-02.12, "Employment of Landing Craft Air Cushion". It is assumed, for the purposes of the simulation, that breakdowns of equipment, either LCAC or otherwise and either at sea or aboard the LMSR or the MLP, do not occur, and that no other similar factors that might inhibit the optimum execution of the mission arise.

### **b. Performance Measures**

The metrics chosen for the simulation study reflect the extent to which the ASE system is able to complete the Load Cargo system function of the objectives hierarchy, and the extent to which the ASE system is able to complete the Transport Cargo system function of the

objectives hierarchy. Table 12 provides a mapping of the simulated MOPs and objective functions. One Measure of Performance (MOP) is chosen for each of these functions. For the Load Cargo function, the MOP is the time required to assemble forces, equipment, and cargo, and to place these assembled forces onto awaiting ASE craft for transport ashore (Assemble). The MOP for the Transport Cargo system function is the time required to move these assembled forces ashore (Employ). The threshold values for these MOPs are obtained from the seabasing Joint Integrating Concept (DOD, 2005).

They are:

- Assemble – assemble and integrate joint capabilities from the sea base to support major combat operations within 24 – 72 hours of arrival within the Joint Operational Area (JOA);
- Employ – employ over-the-horizon from the sea base at least one brigade for Joint Forcible Entry Operations (JFEO) within a period of darkness (8 – 10 hours).

It is important at this juncture to understand where the JIC measures of performance used in the simulation tie into the objectives hierarchy and, where possible, to identify possible future technical parameters that were not treatable in the current decision analysis. Table 12 illustrates how the simulation measures of performance align with the objectives hierarchy. The Assemble measure of performance incorporates objectives in the Function 2.1 Load Combat Cargo of the ASE. The Employ measure of performance incorporates objectives of Function 2.2 Un-load Combat Cargo and Function 3.1 Transport Combat Cargo. The time to assemble and time required for employment can be technical parameters that vary depending upon the particular ASE alternative employed. When more characteristics of the sea base become known, this simulation can be used to establish values for both technical parameters for each ASE alternative and incorporated into the decision analysis. The contribution of these two critical parameters in future analysis work is important as they fill a known gap in available data and can make the decision analysis more comprehensive.

Table 12. Mapping of Simulation MOPS to Objective Functions

<b>Simulation MOP</b>	<b>Objectives Function(s)</b>
<b>Assemble MOP</b>	2.1 (Load Combat Cargo)
<b>Employ MOP</b>	3.2 (Transport Combat Cargo) 2.2 (Un-load Combat Cargo)

The data requirements for the MOPs are the simulation time required for assembly, and simulation time required for employment, respectively. The simulation study accumulates multiple observations of these measures and statistically determines if the modeled system meets the required values as established in the objectives hierarchy.

**c. Model Entities, Assets, and Resources**

The baseline model consists of several entities, assets, and resources. In the model, entities were defined as war fighting equipment, supplies, and troops, since these are the items in the system upon which the performance of the modeled system depends. Specifically, for assembly, the simulation monitored elapsed time between the first vehicle beginning assembly operations and the last vehicle completing assembly operations. Similarly, the simulation monitored elapsed time for employment; the time between the beginning of LCAC loading operations and the last vehicle to debark its ferrying LCAC ashore.

Assets are usually those items in a model which host various resources. A resource is something that is required in the performance of an assigned task, is usually available in limited quantities, and must be shared by all assets and entities which require said resource. An asset can also be counted as a resource, as is the case for the Landing Craft Air Cushion (LCAC) in this simulation. Assets in the model were the LMSR, aboard which all assembly operations occur; the MLP, aboard which queuing of assembled forces and the subsequent loading of LCAC craft occurs; and the LCACs themselves. Resources belonging to the LMSR asset are forklift trucks for the dissemination of supplies to each vehicle in the assembly area, a buffer area for sequencing of vehicular and troop movement from the LMSR to the MLP, and a ramp for the actual transfer of vehicles and troops from the LMSR to the MLP. Only one resource belongs to the MLP asset: a ramp for the transfer of assembled forces aboard an embarked LCAC. Lastly, as stated earlier, the LCAC asset also serves as a resource in the model since the number of

available LCAC are limited, and LCAC usage must be shared among assembled forces requiring transit ashore

### **3. Description of Primary Model Processes**

#### **a. Assembly of Forces**

The major process streams in the simulation model are vehicular loading of Joint Modular Intermodal Containers (JMICs), foot transit of troops to and from the MLP, loading of assembled vehicles aboard an LCAC, and ferrying of assembled forces ashore via LCAC. JMICs are standard containers demonstrated under a JCTD program that are smaller than the 20 foot ISO containers and are likely candidates for future military cargo transport. The Assemble line of operation contains a number of processes which are depicted in Figure 25. Prior to the onset of combat operations (and hence prior to the beginning of the simulation) vehicles arrive at the sea base aboard a modified LMSR in a stowed configuration. Once the sea base has been closed and combat preparations have commenced, each vehicle is un-stowed, fueled, and queued for entrance into the assembly area. The simulation begins at this point with the batching of vehicles into small groups (waves) which then proceed into an assembly area at maneuvering speed (see Appendix B for wave data). Assembly is then accomplished through the hand-loading of supplies and munitions contained within JMICs which are transported by fork truck to the vehicles from a ready storage locker (RSL). Each vehicle type has a unique requirement for supplies and munitions (see Appendix B for vehicle types and their corresponding JMIC requirements). Therefore, certain vehicles require greater time to un-load their respective JMICs than others. The contents of each JMIC is unpacked and loaded onto its respective vehicle one at a time, and each JMIC requires 300 seconds of time for the unpacking of contents, stowage aboard the vehicle, and then the dismantling of the empty JMIC container. Once all required JMICs have been delivered to their respective vehicles the unpacking of contents begins and all free forklift trucks begin replenishing the RSLs with new JMICs that arrive from cargo holds, and also begin to remove retrograde (dismantled JMICs) from the assembly area for return to the cargo holds below. Once all JMICs have been un-loaded and all retrograde removed from the assembly area, the wave of vehicles move together from the assembly area into a ramp buffer area, where coordination of transiting vehicles and troops to the MLP occurs. While this wave of assembled vehicles moves out of the assembly area, the next wave of vehicles moves into the assembly area and the assembly process begins anew.

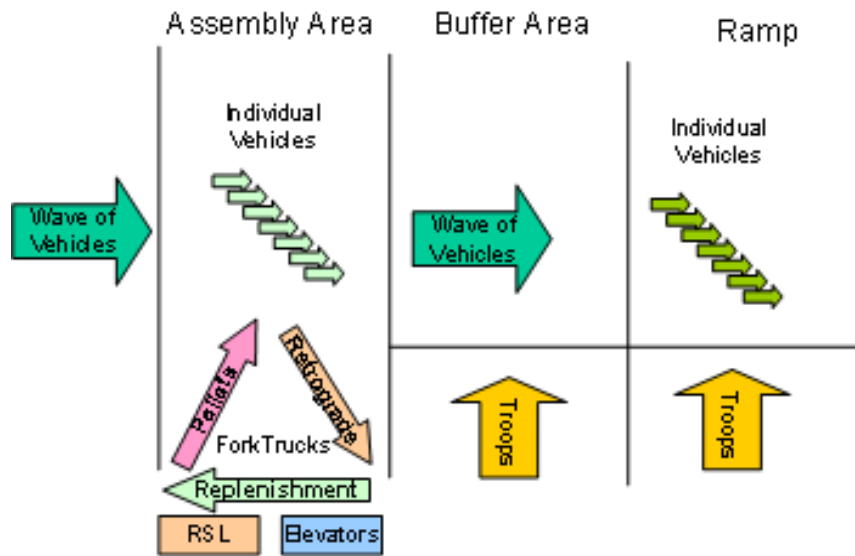


Figure 25. Notional Assembly Process

**b. Employment of Forces**

Once assembled and having successfully transited the ramp between the LMSR and the MLP, the assembled forces and equipment are queued for loading aboard an LCAC at one of two designated LCAC loading points. Vehicles are batched into appropriately-sized groups of vehicles for optimum LCAC combat loading with a maximum load of 75 short tons allowed. Once an LCAC resource has been secured (an LCAC has become available for loading), the next wave of assembled forces moves aboard. Once loaded, the LCAC departs the MLP load point and proceeds to an at-sea LCAC collection area. LCACs wait in the collection area until three LCAC are available for batching into a three-member column echelon for transit to shore. Transit to shore occurs via established landing craft control points in route to the shoreline. Once a loaded LCAC has reached the shoreline, it begins maneuvering operations to land on the beach at the craft penetration point. Once beach landing has been achieved, the LCAC proceeds a short distance to a craft landing zone where assembled forces un-load and proceed to the objective. Un-loaded LCACs then proceed to a beach debarkation craft control point on the beach, where they begin their transit to the craft holding area at sea and await assignment to a craft launch area for vehicular loading, as shown in Figure 26.



Figure 26. Notional Employment Process via LCAC and MLP  
Image from (USMC, 2009)

#### **4. Model Output**

##### **a. Output Summary**

The data collected from each simulation run is as follows:

1. The time required for each individual MEB vehicle (and its attached trailer as applicable) to complete each stage of assembly aboard the LMSR;
2. The time required for each individual MEB vehicle (and its attached trailer as applicable) to transit a 100 foot ramp from the LMSR to the MLP at maneuvering speed;
3. The time required for each batch of 50 troops to transit a 100 foot ramp from the LMSR to the MLP on foot;
4. The time required for each batch of 50 troops to transit a 100 foot ramp from the MLP to the LMSR;

5. The time required for each LCAC to complete its un-loading process at the craft landing zone;

The time required for LCAC return to the craft launch area Troop movement back and forth from the MLP to the LMSR represents the MEB personnel required to participate in combat operations ashore. The inclusion of troop movement from the LMSR to the MLP, and from the MLP to the LMSR, demonstrates that the shared dependence of a single ramp between the LMSR and the MLP between the troop movement process and the vehicular movement process had negligible effects upon overall simulation time required to complete the assembly process. It should be noted that the inclusion of the buffer area permits this condition as assembly processes are allowed to continue inside the closed assembly area while coordination of vehicular and pedestrian traffic across the ramp is performed.

#### **b. Simulation Results and Conclusions**

This study performed 50 iterations of the simulation, computed the means and standard deviations for the two MOPs described above, and computed their respective 95% confidence intervals. The study finds that the notional baseline case fulfills the mission threshold requirements with regard to the Assemble MOP only. The Assemble threshold requirement of 72 hours is met with a mean completion time of 61.92 hours in the baseline case. The Employ threshold requirement of 10 hours is Not met. The Employ MOP completes with a mean completion time of 53.16 hours. It should be noted however, that the baseline case did not study the effects of delivering forces farther than 25 nautical miles from shore, and that additional study is needed in order to achieve a more realistic result, particularly with regard to the Employ MOP.

## **C. COST ANALYSIS**

The Cost Analysis section covers several areas of analysis. The cost estimates are a mixture of estimates by analogy with assumptions and rationales with historical data from past acquisitions converted to FY09 dollars. The first area of analysis is the alternative cost estimates. Given there are several alternatives, some already in the fleet, two in development, and another in Research and Development (R&D), developing cost estimates was complicated. Cost estimates were developed for the existing and developmental alternatives first. Following that, a cost estimate for the R&D alternative, the T-Craft, was performed using a mixture of the other alternatives to form a unique analogous estimate. Next, the Total Ownership Cost (TOC) for each alternative on an individual basis was illustrated graphically. The team assumed a notional fielding date for an ASE platform of 2015 and as such the Operations and Maintenance (O&M) costs start to accrue at that time. Following the TOC, notional mission costs for each alternative system are examined. Last, a cost-benefit analysis compares the TOC for each platform against the notional mission costs.

Table 13 contains a summary of the costs for five of the six alternatives considered, with the exception of T-Craft. The T-Craft is excluded from this initial cost estimate since it is such a unique vessel currently in R&D and as such the T-Craft cost estimate is derived using an analogous estimate using the final costs estimates from the alternatives discussed later on in this section. Table 13 includes the estimates for non-reoccurring engineering (NRE), acquisition, O&M and service life extension (SLEP) which is O&M but listed separately, and salvage/disposal costs. A notional 30 year service life is used for all alternatives.

Table 13. Summary of In Service and Developmental Alternatives Costs

	Cost (\$M FY09) per unit by Alternative				
	JHSV	SSC	LCAC	LCU	LSV
NRE (\$M)	40	69	5	2.5	5
Acquisition Cost (\$M)	170	60	44.5	7.2	19.5
Operation & Maintenance (annual \$M)	38.5	27.5	27.5	1.6	18
SLEP (\$M)	30	12	12	3	10.4
Salvage Cost (\$M)	2.5	0.5	0.5	1.25	2.5
Service Life (years)	30	30	30	30	30

## 1. JHSV

The cost data for JHSV was derived from information obtained from the JHSV program office. It should be noted that this vessel is in the detail design and construction phase and as such the costs should be considered relatively solid with non-recurring engineering estimated at \$40M and vessel unit cost of \$170M. The O&M costs are estimated at \$38.5M annually using a civilian crew. The vessel is currently designed for a 20 year service life; however, the assumption is made that a SLEP will occur at year 20 to extend the service life by 10 more years at a cost of \$30M which is approximately 18% of the initial unit cost, similar to LCAC and LCU SLEP costs. The first vessel is scheduled for service in 2011. The salvage cost is based on the MARAD cost estimate for an average ship of \$2.5M per the article by Roxana Tiron in the National Defense (Tiron, 2001).

## 2. SSC

The SSC is currently in contract design and the cost data is the latest estimate from the program office. The non-recurring engineering is estimated at \$69M with the first craft cost of \$60M. The O&M cost is estimated to be \$27.5M, using the Joint High-Speed Vessel analysis of alternatives from RAND Corporation (Schank, et. al, 2006). Due to the newness of the design, there is not a SLEP estimate. However, considering the similarities of the SSC to the existing LCAC, the assumption is there will be a SLEP and its costs will be the same as LCAC. The salvage cost of the SSC is based on the use of it as a target, meaning once it has been stripped of

all valuables it will be destroyed to support future war fighter training exercises. Such costs are estimated at \$500,000. Current forecasts are for the SSC to have a 30 year service life and the first unit will enter the fleet in 2019; however, given additional resources and funding we are assuming the SSC can enter service to support the 2015 date.

### **3. LCAC**

The LCAC has been around since 1986. Despite this fact, finding adequate historical data was challenging. The data we obtained was from open sources such as the magazines Maritime Log and internet sources such as Wikipedia.com, GlobalSecurity.org, and Naval-technology.com. The non-recurring engineering effort to reestablish production is assumed to be approximately \$3m with an additional \$2M added for design enhancements such as rolling the SLEP changes into the new crafts for a total of \$5M. The craft unit costs are based on the previous costs converted to FY09 dollars at \$44.5M. The team was unable to find O&M costs for the LCAC. To estimate, the same rational is used for the LCAC as for the SSC, namely \$27.5M. Currently, the LCAC is undergoing a SLEP at \$12M each. This will be rolled over to the new units to extend the service life from 20 years to 30 years for better alignment with the other alternatives. There is no reason the new fielded units could not be in service by 2015 considering the fact the LCAC is currently in service. The salvage value for the LCAC is based on the use of it as a target, meaning once it has been stripped of all valuables it will be destroyed to support future war fighter training exercises. This is estimated at \$500,000.

### **4. LCU-2000**

The LCU-2000 has been in operation since the early 1990's. Between the Army Watercraft Master Plan and the Army Program office, the team was able to obtain costs and convert them to FY09 dollars. The current unit cost in 2009 dollars is estimated at \$7.2M. Since the LCU-2000 product line will need a restart to include upgrades per the SLEP, using similar non-recurring engineering costs from the LSV based on the physical dimensions and not displacement, the LCU-2000 NRE is estimated at \$2.5M. Furthermore, the LCU is undergoing a SLEP which has a cost of \$3M. The O&M cost is \$1.6M. The salvage cost of \$1.25M is based on half of the MARAD cost estimate for an average ship of \$2.5M per the article by Roxana Tiron in the National Defense (Tiron, 2001). Given the fact that this class exists today, restarting the class for a 2015 need date is not an issue. It is assumed that with the SLEP the class has a service life of 30 years.

## **5. LSV**

The LSV's have been in production for the longest duration of all the alternatives, from the late 1980's thru 2006. The cost estimate for vessel acquisition cost in 2009 dollars is \$19.5M based on the Army Watercraft Master Plan and the Army Program office. The estimate for the NRE is based on the fact that even though the vessel was in production just 3 years ago, there is a start up value, which is assumed to be equal to the smaller but more complicated LCAC vessel of \$5M. The O & M costs are \$18M. There is also a SLEP at a cost of \$10.4M. Given the fact of the LSV's service and production history, there is no reason new LSV's could not support the 2015 fielding requirement. Furthermore, the LSV will have a 30 year service life after which time, retirement will consist of a \$2.5M cost associated with disposal per the aforementioned MARAD cost for an average vessel.

## **6. T-Craft**

The cost estimate for the T-Craft, a vessel which is still conceptual and in the R&D phase, is based on an analogous estimate that is a composite of several alternatives, since the T-Craft is a unique vessel and none of the alternatives match the design characteristics. Instead the T-Craft estimate is based on all of the alternatives, selecting the closest alternative or alternatives for different cost aspects. The team did have an estimate from ONR for the phase 2 R&D effort of \$150M to develop a prototype for demonstration and testing. The characteristics of the T-Craft used for cost analysis are those previously noted within this paper. The parameters for the T-Craft and the alternatives are listed in Table 14 for comparison.

## 7. Cost Comparison

Table 14. Parameters Comparison

Evaluation Measure	Alternatives					
	T-Craft	JHSV	SSC	LCAC	LCU	LSV
Cargo Capacity (short tons)	336	700	75	60	350	2000
Range (self deploy) (nautical mile)	2500	5600	86	200	9200	8200
Range (intra-theater) (nautical mile)	500	1200	86	200	6500	6500
Speed (loaded) (knots)	40	35	40	40	10	11.5
Length (feet)	240	338	93	88	174	273
Breadth (feet)	70	94	48	47	42	60

To perform a complex analogous estimate using all of the alternatives, a table was developed to determine the cost per parameter. The total cost per alternative is the acquisition cost and the SLEP added together. The total cost was then divided into the parameters values to get a dollar cost per parameter unit for each parameter for each alternative. This is shown in Table 15:

Table 15. Cost per Criteria

Criteria	Cost (\$M FY09) per Criteria by Alternative				
	JHSV	SSC	LCAC	LCU-2000	LSV
Cost / Net Tonnage	0.2857	0.9600	0.9417	0.0291	0.0150
Cost / Speed (knots)	5.7143	1.8000	1.4125	1.0200	2.6000
Self-deploy Range - nautical miles	0.0426	0.8372	0.3767	0.0011	0.0036
intra-theater Range - nautical miles	0.1667	0.8372	0.3767	0.0016	0.0046
Cost / LOA	0.5917	0.7742	0.6420	0.0586	0.1095
Cost / Breadth	2.1277	1.5000	1.2021	0.2429	0.4983

Using the alternatives' characteristics and the cost per criteria ratios as listed above, the best match of T-Craft criteria and those of the alternatives can be identified. Those best fit values can then be averaged together to generate an analogous estimate by parameter. For instance, the cargo capacity of the T-Craft (336 short tons) best aligns with the JHSV at 700 short tons and the LCU at 350 short tons. There was no precise formula used to determine what alternative values would be used to build the analogous estimate. The selections were based on the closeness of the parameter values and engineering judgment. The preference was to use more than one alternative to develop each analogous estimate. The average of the cost ratios for cargo capacity for JHSV (0.2857) and the LCU (0.0291) is 0.157. Next, the cost ratio of 0.157 is multiplied by the cargo capacity requirement of the T-Craft to determine an analogous cost estimate component for cargo capacity of \$52.90M. The same methodology was then used for the other criteria. The average of the cost ratios for speed for the JHSV, SSC, and LCAC is used for T-Craft speed with a final cost ratio of 2.976, and when multiplied by the T-Craft speed requirement of 40 knots, leads to a cost of \$119.02M. For self-deploy range, the LHSV and LCU parameters were closest resulting in a coefficient of 0.018 with a final cost of \$46.03M. The intra-theater range coefficient used the data from the JHSV, SSC, and LCAC which netted a cost ratio of 0.429 which equals a T-Craft cost of \$214.40M. For both the length and breadth of the T-Craft, the JHSV, SSC and LCAC data were used. For length over all, the cost ratio is 0.669 resulting in a cost of \$160.64M and breadth has a cost of \$112.70 with a cost ratio of 1.610. Then each analogous estimate for each parameter is averaged netting a final cost estimate of T-Craft at \$117.61M. Table 16 contains the summary of the T-Craft analogous criteria estimates.

Table 16. T-Craft analogous criteria estimate

Evaluation Measure	Estimated T-Craft Cost		
	Raw Data	Estimated Cost Ratio	Estimated Cost (\$M)
Cost given Net Tonnage (short tons)	336	0.157	\$52.90
Cost given Speed (knots)	40	2.976	\$119.02
Self-deploy Range - (nautical miles)	2500	0.018	\$46.03
Intra-theater Range - (nautical miles)	500	0.429	\$214.40
Cost given LOA (feet)	240	0.669	\$160.64
Cost given Breadth (feet)	70	1.610	\$112.70
estimated T-Craft cost			\$117.61

The design service life for T-Craft is assumed to be 30 years with no SLEP assumed nor estimated. Additionally, the O & M cost of \$55M is estimated to be approximately twice that of the SSC due to the T-Craft's comparative size and complexity. Retirement of the craft will be to train the war fighters and is similar to the LCAC and SSC costs of \$500,000. The complete cost table of all of the alternatives is listed in Table 17.

Table 17. T-Cost table of all alternatives

Evaluation Measure	Alternatives - all \$ are FY09					
	T-Craft	JHSV	SSC	LCAC	LCU	LSV
NRE (\$M)	40	40	69	5	2.5	5
Acquisition Cost (\$M)	117.6	170	60	44.5	7.2	19.5
Operation & Maintenance (annual \$M)	55	38.5	27.5	27.5	1.6	18
SLEP (\$M)	0	30	12	12	3	10.4
Salvage Cost (\$M)	0.5	2.5	0.5	0.5	1.25	2.5
Service Life (years)	30	30	30	30	30	30

The Total Ownership Cost is developed using FY11 dollars for each alternative. It is assumed that with the recent stimulus spending that inflation from 2009 to 2011 was zero and thus dollars in 2011 equal the dollars in 2009. However, inflation rate following 2011 is assumed to be a constant 2.8%. This assumption is supported by the whitehouse.gov site's appendix C regarding circular A-94 (revised) where the 30 year Real Interest Rate is cited as 2.8%. The Real Interest Rate was used to support the constant dollar flows and the 30 year time period was selected in support of the 30 year product lifecycle. The TOC categories to highlight the 30 year life cycle are initial design or the NRE, production, O & M, SLEP, and retirement. The TOC is for only one unit or craft. All of the data used for the TOC comes from Table 17.

The TOC of the T-Craft is calculated at \$1047.90M in FY09. The T-Craft LCCP is shown in Figure 27.

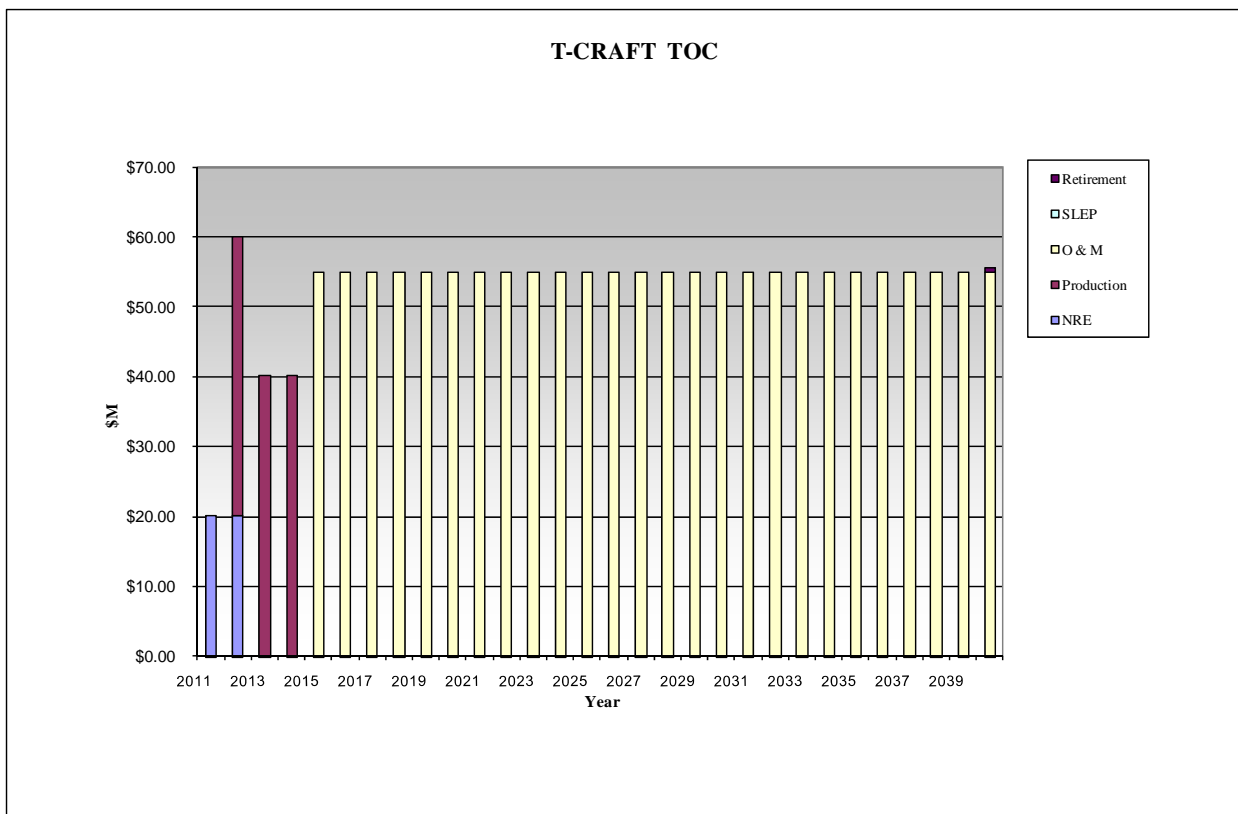


Figure 27. T-Craft TOC

The TOC of the JHSV is calculated at \$1004.36M in FY09. The JHSC TOC is as shown in Figure 28.

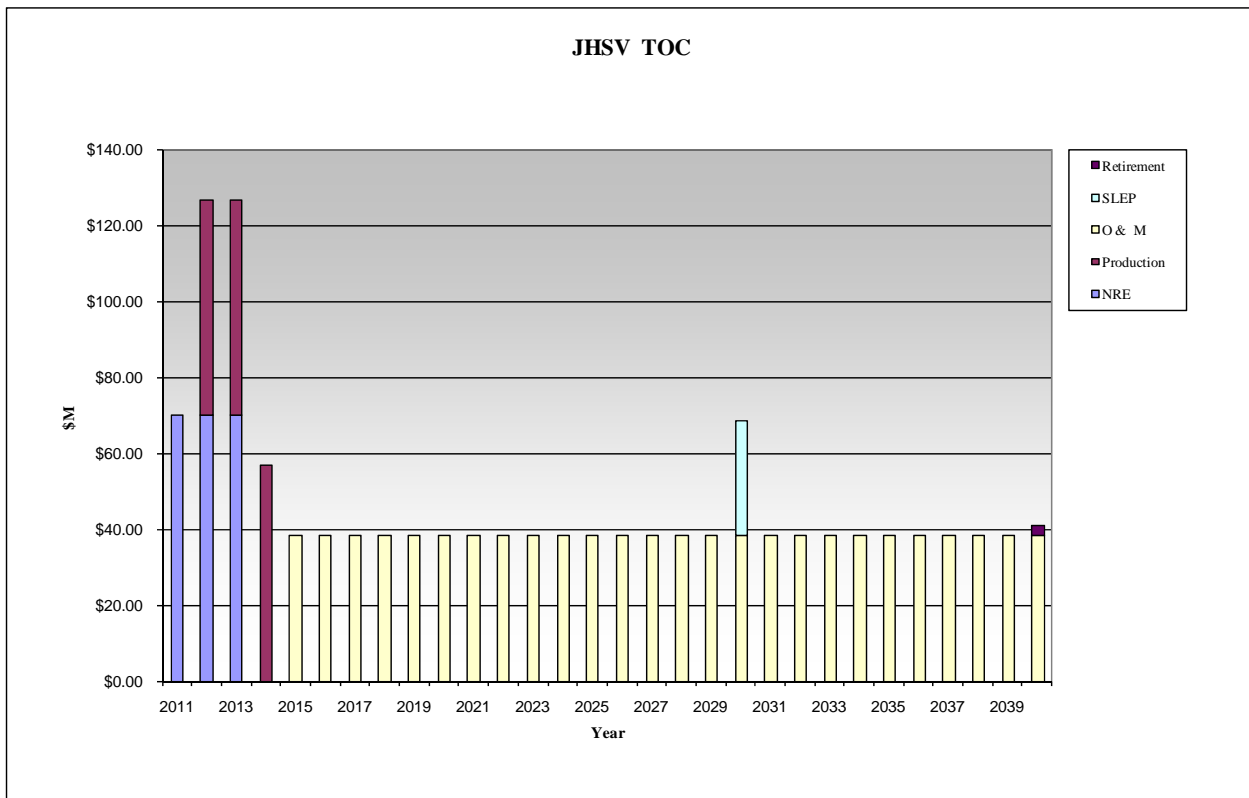


Figure 28. JHSV TOC

The TOC of the SSC is calculated at \$578.19M in FY09. The SSC TOC is as shown in Figure 29.

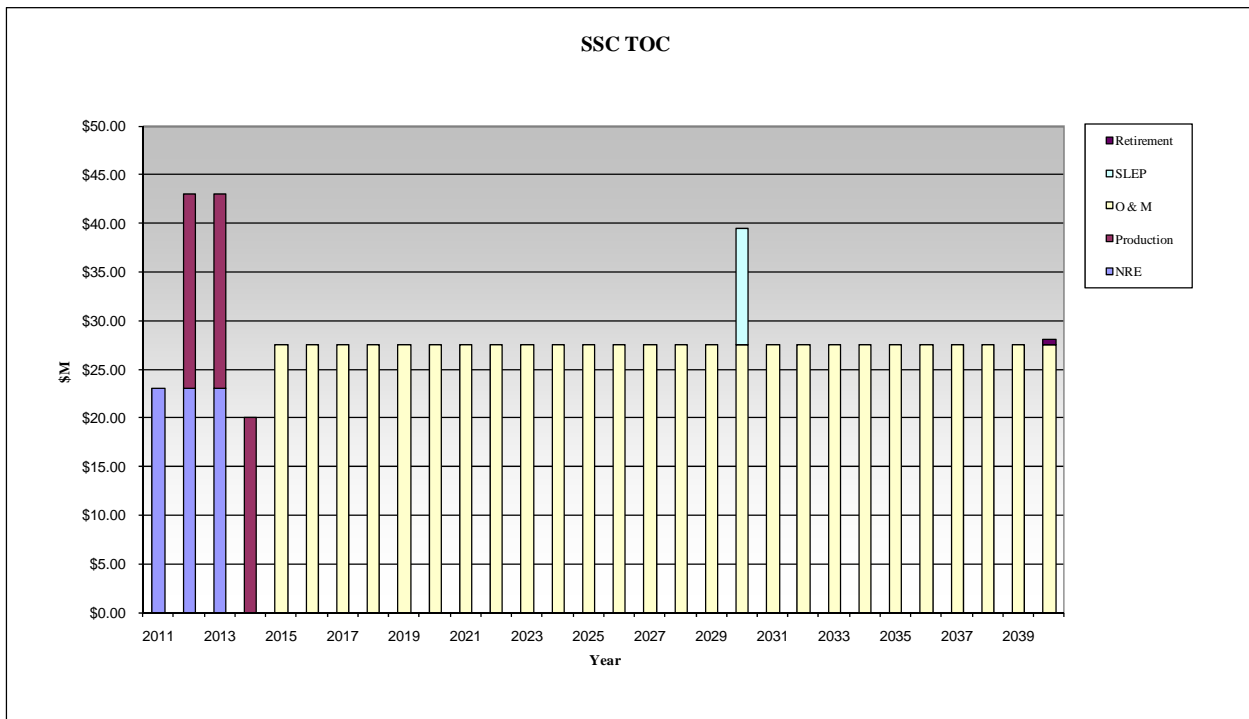


Figure 29. SSC TOC

The TOC of the LCAC is calculated at \$503.40M in FY09. The LCAC TOC is as shown in Figure 30.

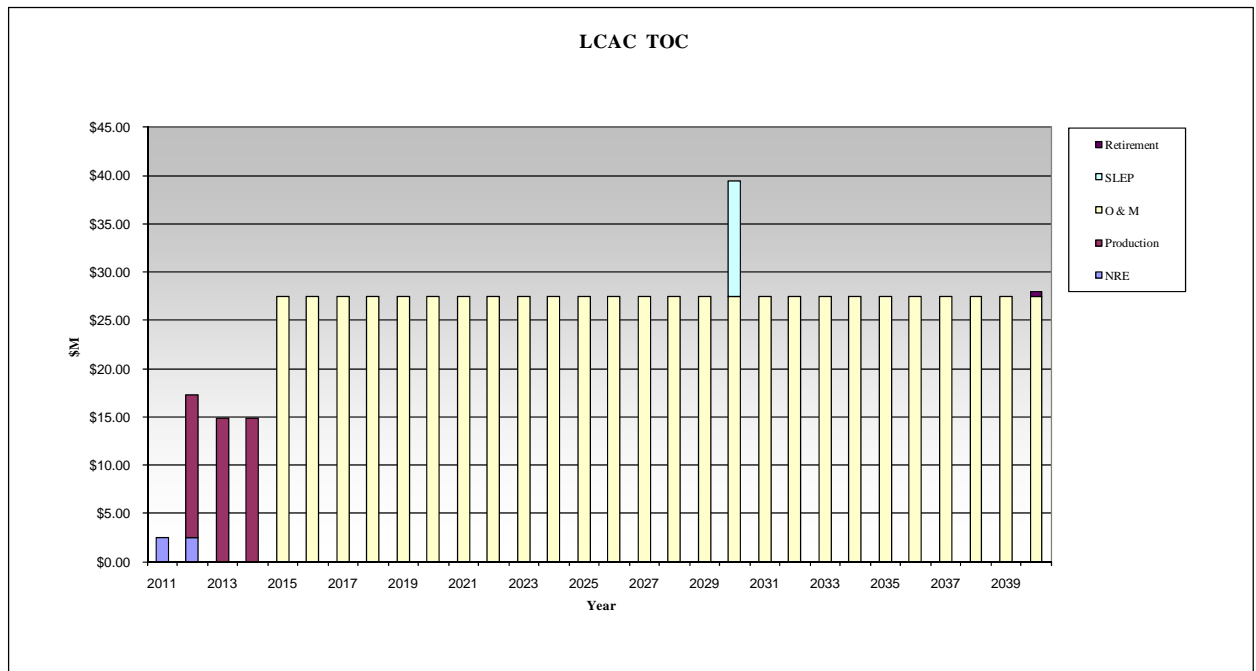


Figure 30. LCAC TOC

The TOC of the LCU-2000 is calculated at \$37.51M in FY09. The LCU-2000 TOC is as shown in Figure 31.

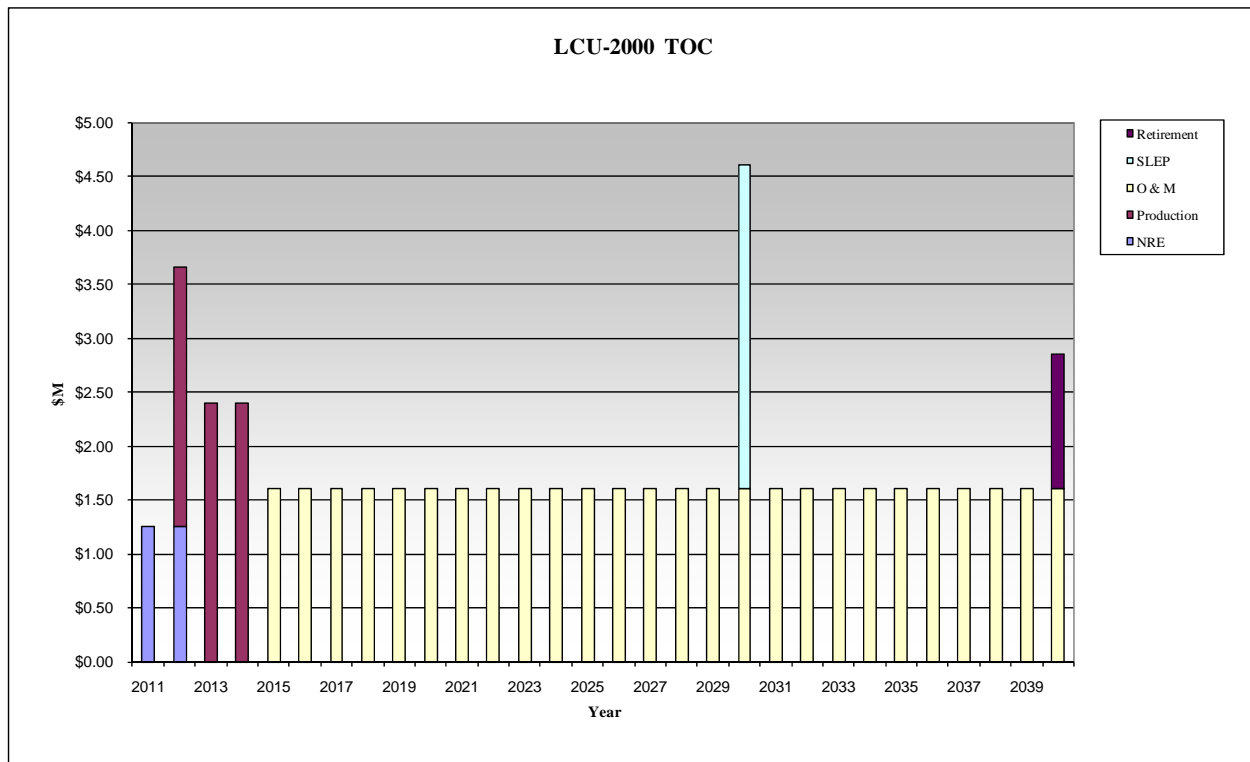


Figure 31. LCU-2000 TOC

The TOC of the LSV is calculated at \$324.71M in FY09. The LSV TOC is as shown in Figure 32.

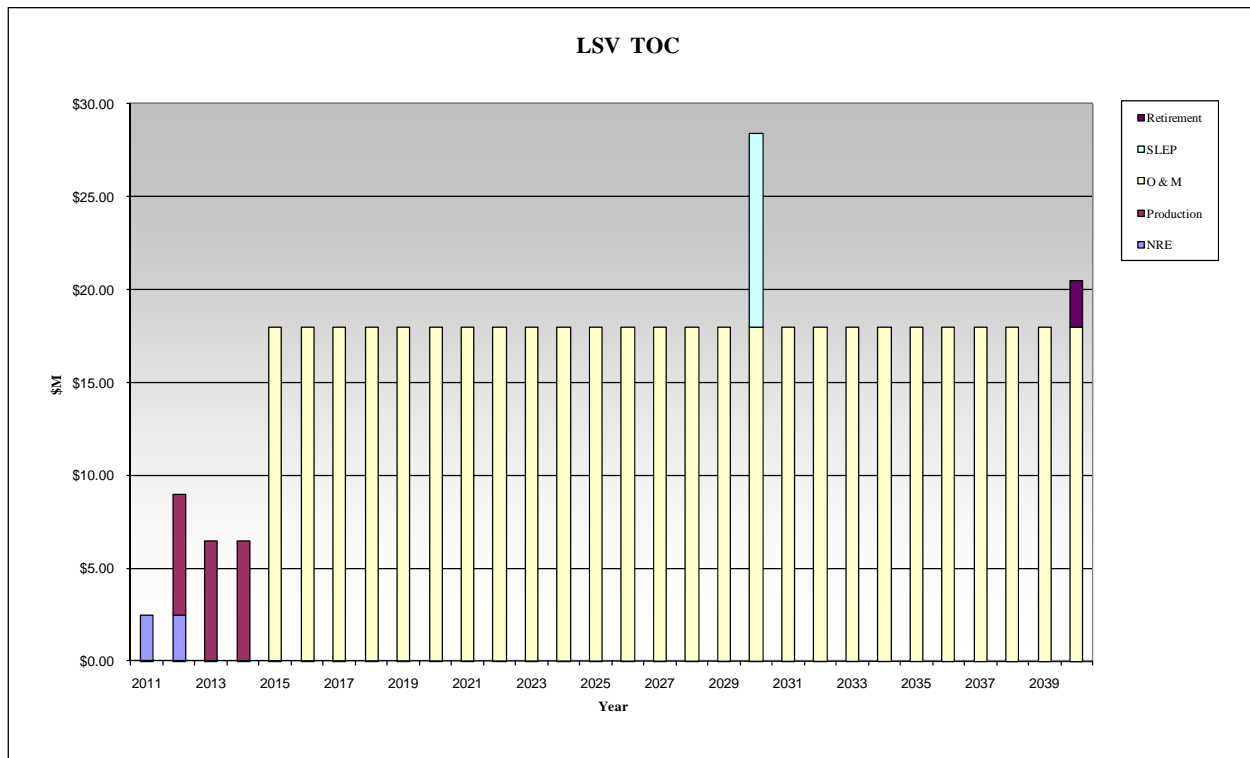


Figure 32. LSV TOC

The TOC for each alternative, as shown, are only part of the picture needed to support decision analysis. To better support decision making and normalize across platforms, the different alternatives are analyzed against a mission scenario requiring the transport of a certain amount of cargo over a certain time period. Determining the number of vessels it takes to move the specified cargo within the specified time gives a better performance metric that can be utilized as part of a cost-benefit analysis. The alternatives are analyzed against the combat and humanitarian missions with notional mission specifications regarding amount of materiel to be moved and time requirements. For each analysis it is assumed that each vessel will travel at maximum speed and will be fully loaded to its maximum cargo capacity. Only transport time is considered. For the combat scenario, the analysis objective is to determine the number of crafts it takes to move 13,000 tons of cargo 25 nautical miles in a 10 hours period, not including the time to perform cargo operations. Table 17 shows the number of craft required to execute this mission and the acquisition cost for that number of vessels. JHSV is not considered as it was screened out for combat missions.

Table 18. Major Combat Mission- Acquisition cost of required number of connectors

FY09 \$M	Alternatives required to move 13,000 tons in 10 hours					
	T-Craft	JHSV	SSC	LCAC	LCU	LSV
Connector Acquisition Cost	\$117.61	\$170.00	\$60.00	\$44.50	\$7.20	\$19.50
Number of Connectors	6	0	22	28	19	3
Total Cost	\$705	N/A	\$1,320	\$1,246	\$137	\$59

A humanitarian aid mission was also analyzed determining the number of craft needed to move 100,000 tons of cargo, 25 nautical miles in a 48 hour period. Table 19 shows the number of vessels required for each alternative and the acquisition cost for that collection of vessels. The “fleet” cost estimates will be visited again in the Cost vs. Utility section where cost-benefit analysis is considered

Table 19. Humanitarian Mission Acquisition cost of required number of connectors

FY09 \$M	Alternatives required to move 100,000 tons in 48 hours					
	T-Craft	JHSV	SSC	LCAC	LCU	LSV
Connector Acquisition Cost	\$117.61	\$170.00	\$60.00	\$44.50	\$7.20	\$19.50
Number of Connectors	9	5	35	44	30	5
Total Cost	\$1,058	\$850	\$2,100	\$1,958	\$216	\$97.50

## **V INTERPRETATION**

The Interpretation phase of the system engineering process utilizes information generated from previous phases to assist in decision making. The goal of interpretation for this project is to identify the best decision alternative through the use of utility theory, value scoring, and sensitivity analysis. This phase of the project is described by Sage and Armstrong, as the evaluation in accordance with the value system of the decision makers and selection of the path forward (Sage and Armstrong, 2000).

### **A. DECISION ANALYSIS**

Decision analysis is a normative and prescriptive framework that allows the decision maker to select the preferred course of action in a complex decision situation (Sage and Armstrong, 2000). The evaluation of the sea base enabler platforms was done via a rigorous MAUT (multi-attribute utility theory) process which pooled together the collective abilities and knowledge of the stakeholders and team members. The MAUT process sets forth guidelines for conducting the value scoring, constructing of a data matrix, and a decision matrix. These processes will be explained in depth to fully comprehend how the decision process was executed.

### **B. SCORING, SCOPING AND ASSUMPTIONS**

For this decision analysis there are assumptions which must be defined:

- Only the sea-borne surface connectors are evaluated. The report detailed airlift connectors in a previous section (Chapter III), but it was decided among the team that airlift connector decision analysis should be conducted separately when the platforms are more mature (see feasibility screening – Chapter IV, Section A).
- Only the combat and humanitarian operational scenarios are evaluated. These scenarios are the polar opposite of each other based on the two characteristic dimensions considered and therefore address the all requirements that would be inclusive in the police action and disaster relief scenarios.
- Beachability was determined to be a screening requirement for the combat scenario. Current alternatives in service that do not possess beachability or concept alternatives

that do not address the capability in the design criteria were screened out of the combat value analysis.

Three of the six alternatives (T-Craft, SSC, and JHSV) are not currently operational with the US force structure and are at various stages within the acquisition or developmental process. The operational alternatives (LCAC, LCU, and LSV) have performance data readily available which was used to populate the raw data matrix, which addresses the key performance parameters discussed in the following section. As all of these vessels are brought into service or upgraded the value analysis should be repeated using real world performance measurements to ensure that this analysis model remains consistent. The raw value matrix for these alternatives is shown in Table 20.

Table 20. Raw Value Matrix

<b>Evaluation Measure</b>	<b>Alternatives</b>					
	<b>T-Craft</b>	<b>JHSV</b>	<b>SSC</b>	<b>LCAC</b>	<b>LCU</b>	<b>LSV</b>
Range: self deploy (nautical miles)	2500	5600	86	200	9200	8200
Range: intra-theater (nautical miles)	500	1200	86	200	6500	6500
Speed: loaded (knots)	40	35	40	40	10	11.5
Cargo Capacity (short tons)	336	700	75	60	350	2000
Crew Size	3	41	5	5	13	32
Beachable (1=yes, 0=no)	1	0	1	1	1	1

### C. VALUE SCORING

The team performed detailed research to assemble a list of global platform parameters that pertained to the various operational scenarios, as detailed in Section I (Introduction - Scope). This list was compiled and sent to the stakeholders in the form of a survey. The stakeholders were asked to rank the requirements from most desired to least desired utilizing a number scale; see Section II (Formulation – Requirements Analysis). The results of these rankings were compiled and the six highest ranked were detailed as global requirements due to their applicability across multiple ASE mission sets, see Table 21. The utility curves were also generated from this ranking data.

Table 21. Primary Requirements to be analyzed

Requirement	Unit of measure	Evaluation measure
Range: self deploy	Nautical miles	Farther is better (2500 nautical miles max)
Range: intra-theater	Nautical miles	Intra-theater $\geq 200$ nautical miles
Speed: loaded	Nautical miles per hour (knots)	Faster is better
Cargo Capacity	Short tons	Bigger is better
Operational Crew Size	Integer - # of personnel	Fewer crew members are better
Beachability	Binary (Yes/No)	Dependant on mission

### 1. Utility Curves

Utility curves and the theory governing their use allow the decision maker to see the impact of selecting a specific value or range for a requirement. Since not all consequences are monetarily governed these curves allow the decision makers to see the utility of a specific scalar value and in turn mitigate by selecting a capability that maximizes the utility (Sage and Armstrong, 2000). The utility curves for this analysis are used to graphically represent the utility of a specific attribute on a scale of 0 to 1, with 0 being no utility and 1 being maximum utility. The utility values for each attribute can easily be read from the curve and then carried over to the decision matrix for evaluation. Figures 33-37 are the utility curves for each requirement detailed in Table 21 with the exception of beachability which is binary and as such has no meaningful curve. The team generally utilized piecewise linear curves for simplicity of computation.

#### a. Self-deployable range

Self-deployable range is the maximum distance a platform may traverse with minimum crew and load and without refueling. The utility curve for this requirement is shown in Figure 33. The maximum utility (1) is realized at 2500 nautical miles. This is predicated on the need for the platform to be capable of self deploying from any US naval installation worldwide without the need for additional logistical infrastructure for support. The shape of the curve is essentially 'S' shaped based on the threshold and objective values for the parameter. The utility gets slowly greater as range increases until the threshold value of 1000 nautical miles is achieved. At that point there is an inflection point in the curve and the slope increases. As the

range nears the objective of 2500 nautical miles the curve begins to flatten out again until the maximum utility of 1 is reached at the objective value of 2500 nautical miles.

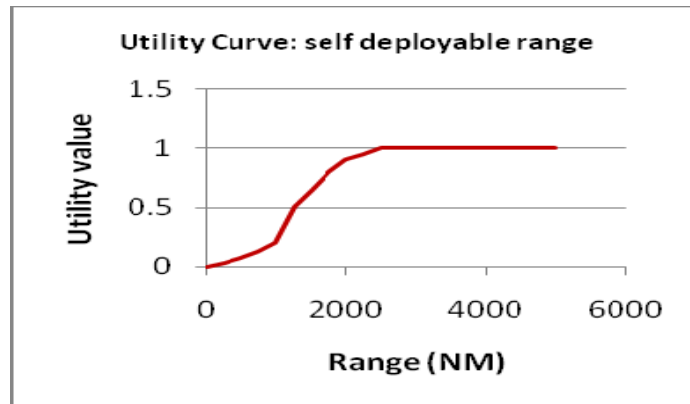


Figure 33. Utility Curve: Self-deployable range

**b. Intra-theater range**

Intra-theater range is the maximum cumulative range of the platform without refueling, analyzed as point to point from sea base to insertion point. The utility curve for this requirement is shown in Figure 34. 250 nautical miles (125 nautical miles each way) or higher has a maximum utility (1) because it is assessed that this may be the maximum distance from the sea base to the shore while staying within the sea-shield field of regard. The curve ramps up rapidly to a moderate utility at the threshold range value of 25 nautical miles. It begins to level out after this point, with utility increasing slowly as range increases to the maximum utility range value of 250 nautical miles.

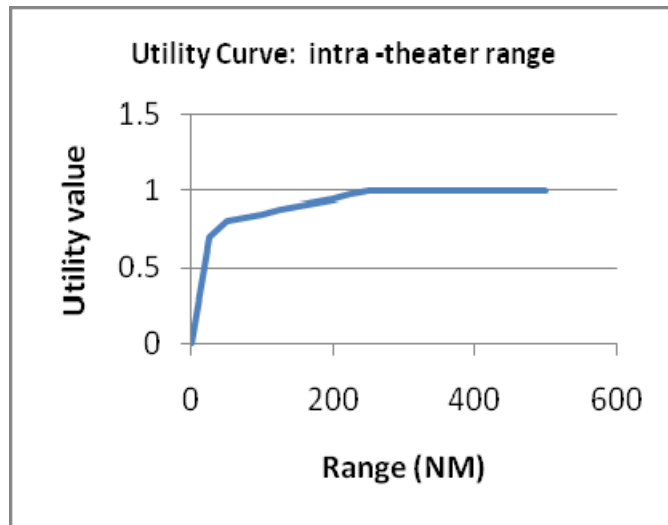


Figure 34. Utility Curve: Intra-theater range

**c. Speed with Cargo (Speed – Loaded)**

Speed with Cargo is the maximum speed of the platform with a full cargo load. The utility curve for this requirement is shown in Figure 35. Maximum utility (1) is realized at 40 knots. Stakeholder analysis indicated 40 knots as the threshold for optimizing logistical operations. It was difficult for the team to assess how utility would change based on speed as stakeholders had not been clear on this point. The team assumed a moderate increase until a speed of approximately 20 knots was reached after which utility would increase more rapidly until the maximum utility is reached at 40 knots.

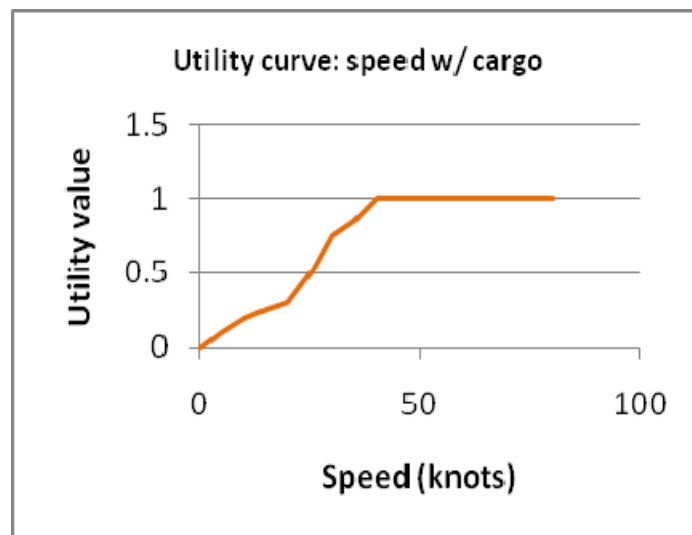


Figure 35.

Utility Curve: Speed with cargo

**d. Cargo capacity (s tons)**

Cargo capacity is the maximum amount of cargo the platform is capable of carrying. The utility curve for this requirement is shown in Figure 36. Maximum utility (1) is realized at 600 short tons. Stakeholders indicated 600 short tons as the threshold for optimal mission support. The curve has some minor deviations but is mostly a fairly linear slope from zero utility at 0 tons cargo capacity to the maximum utility at 600 tons cargo capacity.

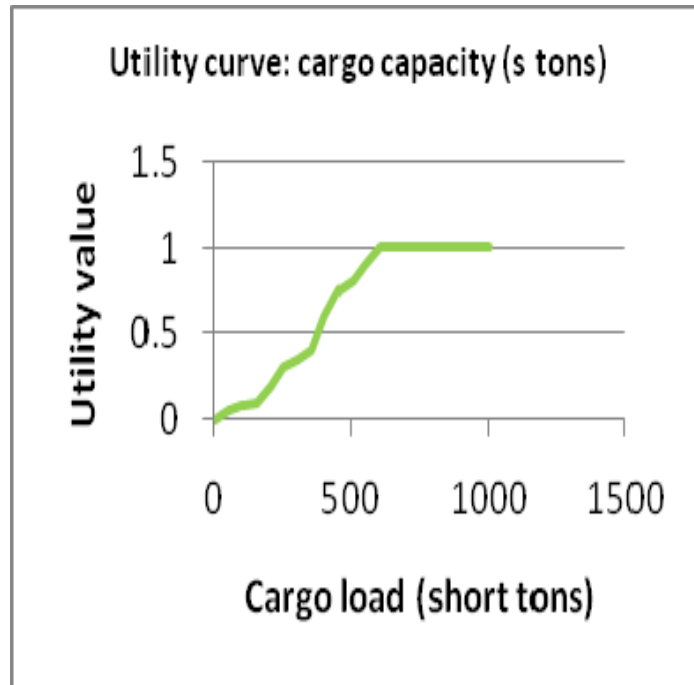


Figure 36. Utility Curve: Cargo capacity (s tons)

**e. Crew Size**

The crew size is the minimal amount of crew required to fully operate the platform. The utility curve for this requirement is shown in Figure 37. Stakeholders indicated that minimal organic crew was better in order to fully exploit the capacity of the platform for the specific mission. Fewer crew members are better because manning is the primary driver of operational costs. With the increasing prevalence of unmanned systems and improvements in autonomous technologies the team decided to be futurists and set the maximum utility (1) for a crew size of 0. The crew size utility curve has an inverse slope, with utility dropping as crew size increases. A utility of 0 is reached when crew size exceeds 100. The slope of the curve drops gradually until a crew size of 20 is reached at which point it begins to drop more rapidly until a crew size of 40 is reached. Then it slowly decreases to the maximum crew size.

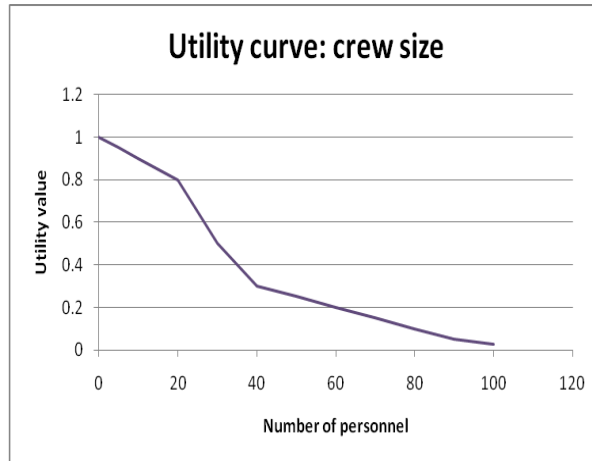


Figure 37. Utility Curve: Crew size

A note on crew size: After the analysis was complete and documented the team decided that total crew size, as it is, might not be the best measure of crew impact. The reason is that crew size will likely increase with the size of the vessel, but generally so will beneficial parameters such as cargo capacity. A fairer measure might be the ratio of number of crew to cargo capacity. Since crew size was not heavily weight for either mission, the impact of making such a change would not significantly impacted the analysis results presented.

The utility value for each alternative was read from the curve and used to populate the utility score matrix, as shown in Tables 21.

Table 22. Utility Scores Matrix

Evaluation Measure	Utility Score Matrix					
	T-Craft	SSC	LCAC	LCU	LSV	JHSV
Range: self deploy (nautical miles)	1.00	0.01	0.02	1.00	1.00	1.00
Range: intra-theater (nautical miles)	1.00	0.84	0.95	1.00	1.00	1.00
Speed: loaded (knots)	1.00	1.00	1.00	0.20	0.21	0.85
Cargo Capacity (short tons)	0.39	0.07	0.06	0.40	1.00	1.00
Crew Size	0.97	0.95	0.95	0.87	0.46	0.30
Beachable (1=yes, 0=no)	1.00	1.00	1.00	1.00	1.00	0

The humanitarian mission analysis includes beachability due to the reasons explained previously, which makes this attribute a binary step function for this mission. The alternative will either score a 0 or 1 for this attribute.

#### **D. BASELINE ANALYSIS**

The alternative value scoring baseline for combat and humanitarian missions is shown in Figures 38 and 39 respectively. This initial set of results is called the baseline as it is the basis for comparison for the sensitivity analyses that follow. The total value scores were computed with the formula shown in Equation 1.0.

$$V(a_i) = \sum w_j U_j(a_i)$$

Equation 1.0 Value Scores Formula

$V(a_i)$  is total value score of a specific alternative, noted as subscript  $i$ .

$w_j$  is the global weight that is applied to the specific attribute ( $j$ ) of the alternative.

$U_j(a_i)$  represents the utility score of the specific attribute ( $j$ ) for the alternative ( $i$ ).

For the combat analysis the global weighting was determined based upon what the stakeholders defined as key attributes for this mission. Speed was given a global weight of 30% while intra-theater range was weighted as 25% of the total composite score. As with any combat type scenario the strike force wants to be able to quickly embark on a mission and know that they have the speed and range to get “out of harm’s way”, as well as the range to reach their objectives, which is why these two attributes were rated as 55% of the total composite score. Beachability was the one attribute which was determined to be absolutely essential when conducting combat and potential covert operations. The ability to come ashore where ever and when ever was so important to the stakeholders that it was elevated to a screening criterion for the combat mission analysis. The JHSV (Joint High Speed Vessel) even though still in the concept phase was removed from the analysis because it did not address this ability in the system requirements. The T-Craft was deemed as the optimal alternative for the combat mission set.

The T-Craft alternative received a utility score of 1 for three out of five of the combat scenario measures (self deploy range, intra-theater range, speed). The T-Craft objective is to only require an operational crew of three personnel, and hence did not receive a utility score of 1. The only measure where the T-Craft is lacking, relative to the other alternatives, is cargo

capacity. Based on the analysis the T-Craft received a value score of 87.3%, which is over 17% better than the next highest scoring alternative, the LCAC. The other alternatives scored fairly similarly with values between 62% and 68%.

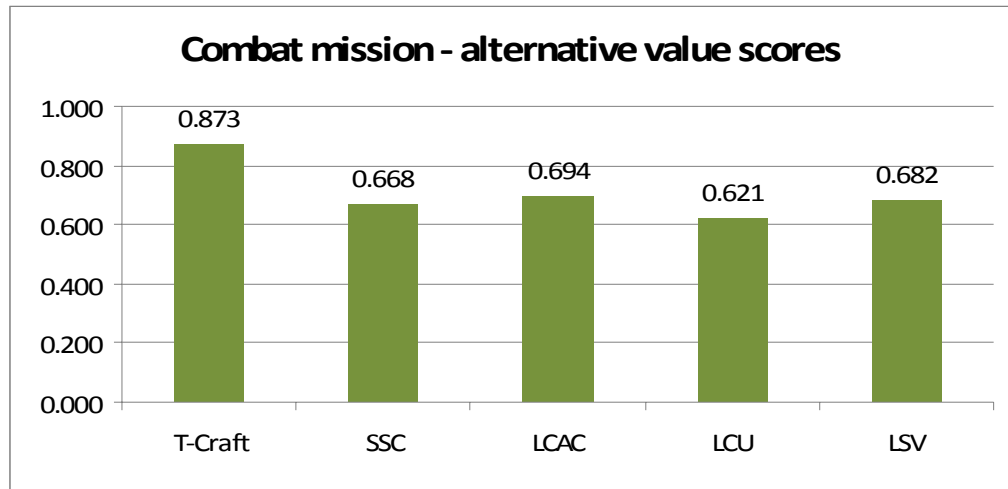


Figure 38. Combat Mission – Alternative’s Value Scores

Table 23 depicts the application of the global weights to the utility scores to calculate the value scores for each alternative that is included in the combat mission analysis.

Table 23. Combat Mission Baseline Alternative’s Value Scores

Evaluation Measure	Global Weight	Combat Mission Utility Scores				
		T-Craft	SSC	LCAC	LCU	LSV
Range: self deploy (nautical miles)	0.10	1.00	0.01	0.02	1.00	1.00
Range: intra-theater (nautical miles)	0.25	1.00	0.84	0.95	1.00	1.00
Speed-loaded (knots)	0.30	1.00	1.00	1.00	0.20	0.21
Cargo Cap (short tons)	0.20	0.39	0.07	0.06	0.40	1.00
Crew Size	0.15	0.97	0.95	0.95	0.87	0.46
Total Value Score		0.873	0.668	0.694	0.621	0.682

The humanitarian value scoring included the JHSV because beachability was determined to be a desired but not essential attribute for this mission. While beachability was included as a

criterion, the global weight assigned for the humanitarian mission was 10%. Beachability was rated low simply because data from previous humanitarian missions detailed port accessibility as a non-compromising issue. The primary attributes for the humanitarian mission were cargo capacity (40%) and speed (20%). The value scores for each alternative are shown in Figure 39.

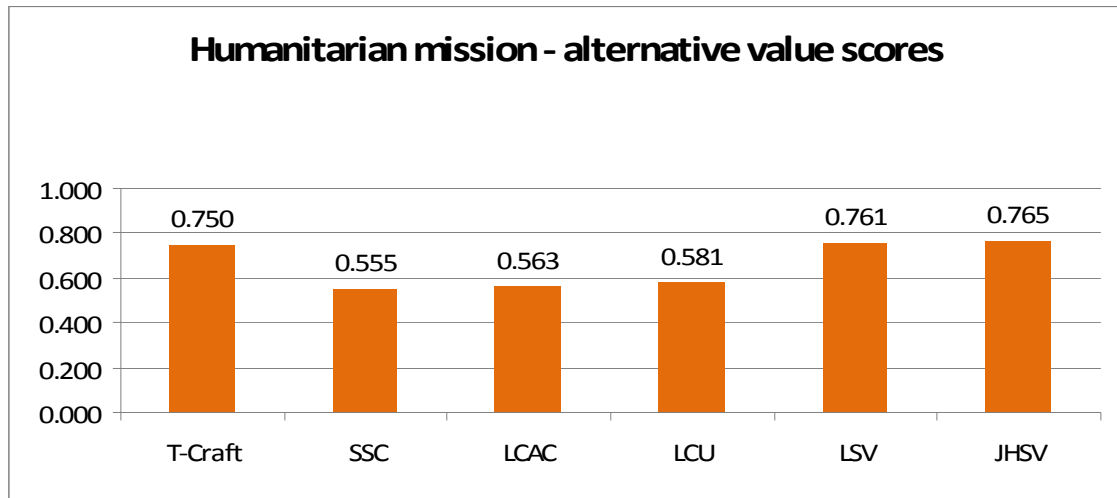


Figure 39. Humanitarian Mission – Alternative’s Value Scores

Table 24 depicts the application of the global weights to the utility scores to calculate the value scores for each alternative that is included in the humanitarian mission analysis.

Table 24. Humanitarian Mission Baseline Alternative’s Value Scores

Evaluation Measure	Global Weight	Humanitarian Mission Utility Scores					
		T-Craft	SSC	LCAC	LCU	LSV	JHSV
Range: self deploy (nautical miles)	0.05	1.00	0.01	0.02	1.00	1.00	1.00
Range: intra-theater (nautical miles)	0.1	1.00	0.84	0.95	1.00	1.00	1.00
Speed-loaded (knotts)	0.2	1.00	1.00	1.00	0.20	0.21	0.85
Cargo Cap (short tons)	0.4	0.39	0.07	0.06	0.40	1.00	1.00
Crew Size	0.15	0.97	0.95	0.95	0.87	0.46	0.30
Beachable	0.1	1.00	1.00	1.00	1.00	1.00	0.00
Total Value Score	1	0.750	0.555	0.563	0.581	0.761	0.765

The stakeholder rationale for this weighting is logistically based in that they want to be able to deliver the maximum amount of supplies to a crisis area in the shortest time possible. Analysis indicates that the JHSV would be the optimal alternative for this mission set (score 76.5%) but by a narrow margin. The T-Craft, which scored highest for the combat scenario, scored third in the humanitarian analysis with a score of 75% behind JHSV (76.5%) and LSV (76.1%).

## **E. SENSITIVITY ANALYSIS**

Sensitivity analysis affords the decision maker a degree of confidence in the decision process as well as quantifies the potential uncertainty of the global weights and the decision outcome. This is especially useful since utility and weights are subjectively determined. A sensitivity analysis was performed for both operational scenarios in order to fully understand how the global weighting impacted the total value scores for the alternatives. The global weights for each alternative were incremented from 0 to 1 in 0.05 steps. This method allowed for development of a linear model to depict how the specific attribute for each alternative affects the value assessment for that alternative. The lines are then be graphed on a common scale and analyzed for any intersection point where the global weighting variation would affect the overall relative value score of the alternatives.

For the combat mission, Figures 40 and 41 shows that the global weighting for speed and intra-theater range do not affect the selection of T-Craft as the highest scoring alternative. Figure 42 shows an intersection point at a global weight of 50%. The LSV would then become the alternative of choice if cargo capacity was globally weighted higher. Cargo capacity becomes a significant issue when supporting or sustaining ground combat operations with armor and supplies. Cargo capacity would likely not be a primary concern when inserting a light reconnaissance or special operations team, but if the mission dictated berthing several of these types of teams from one vessel to multiple insertion points then cargo capacity may impact mission effectiveness. Of course, the significantly higher speed of the T-Craft offsets its lower cargo capacity to some extent as it can deliver its cargo and return for more.

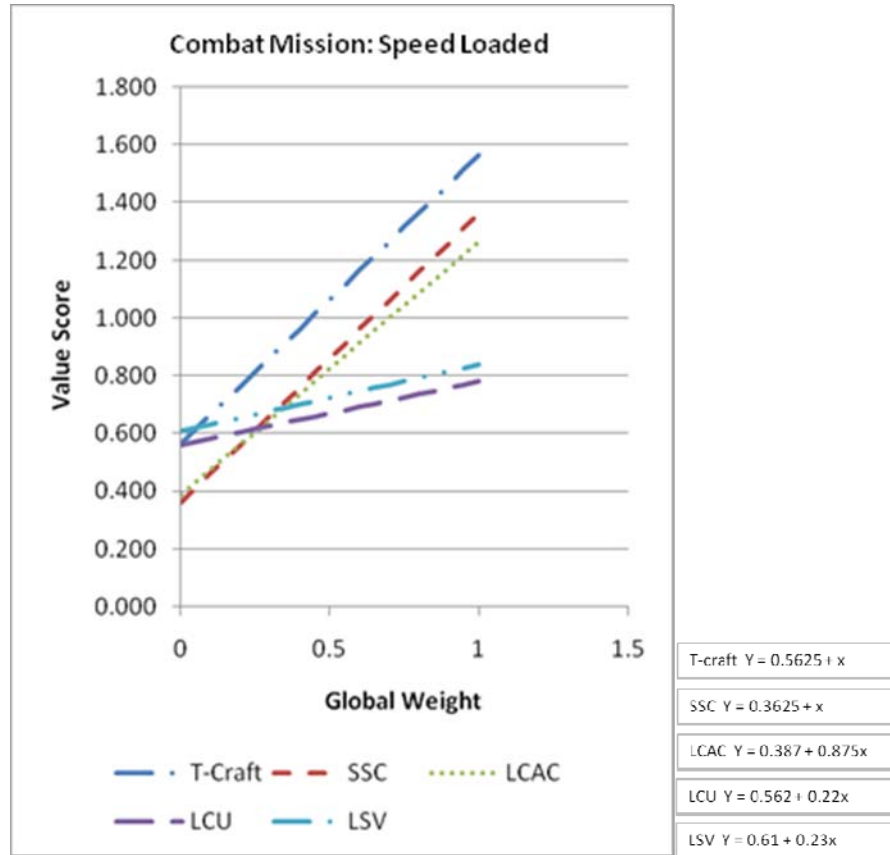


Figure 40. Combat Mission: Speed Loaded

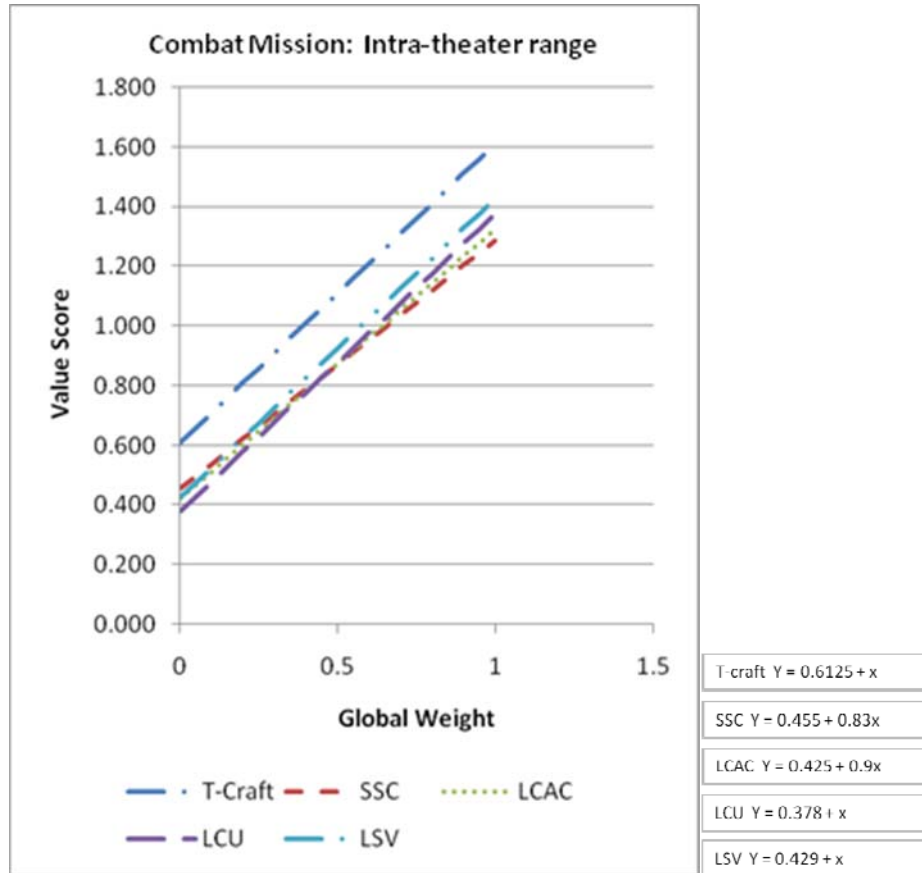


Figure 41. Combat Mission: Intra-theater range

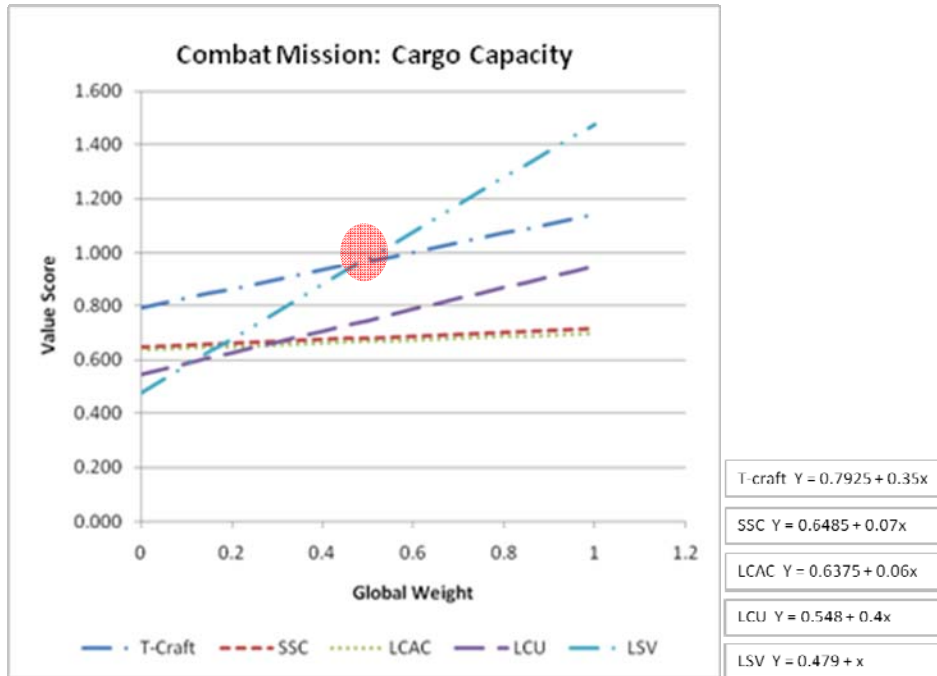


Figure 42. Combat Mission: Cargo capacity

The humanitarian mission was also subjected to a sensitivity analysis. The results narrowly indicate that the JHSV may be the best alternative for this mission set, but analysis indicates one operational platform is a close contender. In cargo capacity analysis (Figure 43), it can be seen that the LSV runs parallel with that of the JHSV, with an intersection point at 38% where JHSV capability exceeds that of T-Craft. The speed loaded analysis (Figure 44) shows that T-Craft is converging to the JHSV capability at a global weight of ~ 40%. Both platforms surpass the speed capability of the LSV, as indicated by the intersection point at 20%. Figure 45, illustrating intra-theater range, shows T-Craft and LSV running directly parallel with the JHSV capability.

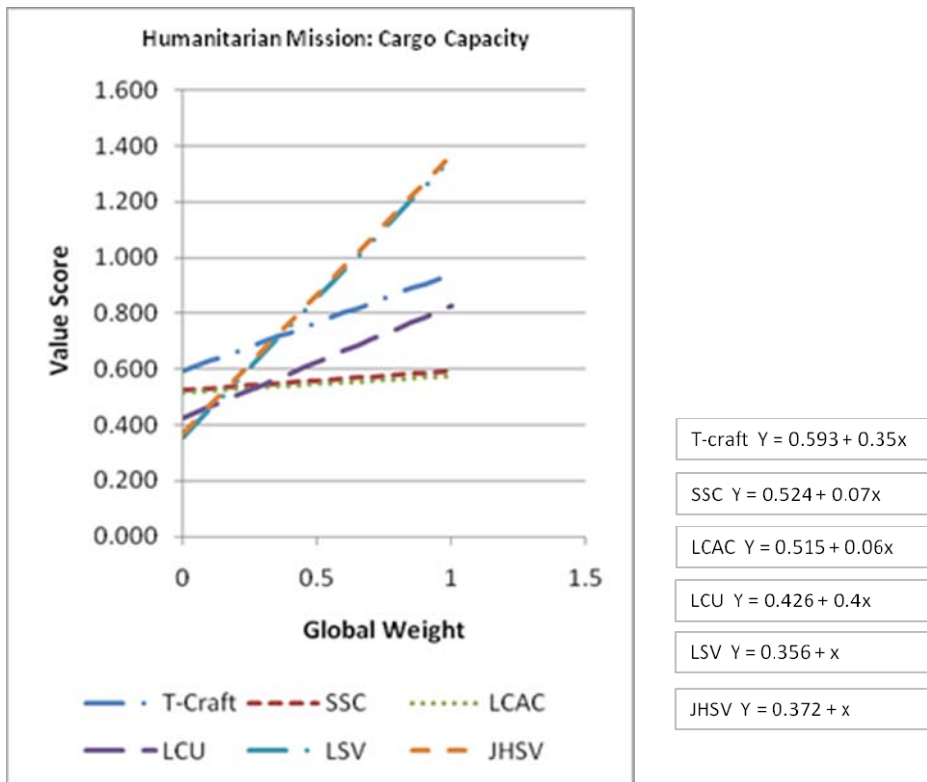


Figure 43. Humanitarian Mission: Cargo capacity

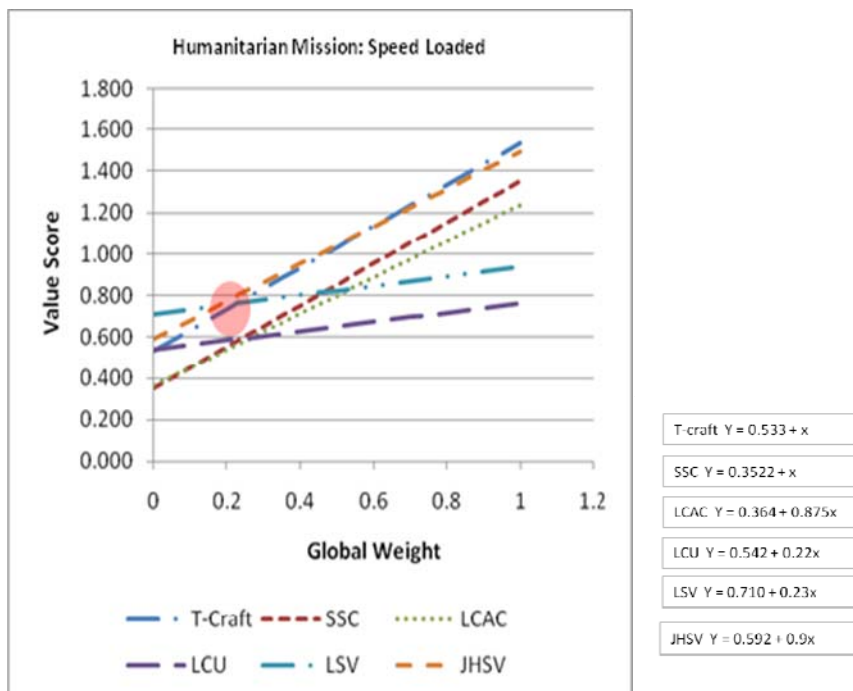


Figure 44. Humanitarian Mission: Speed loaded

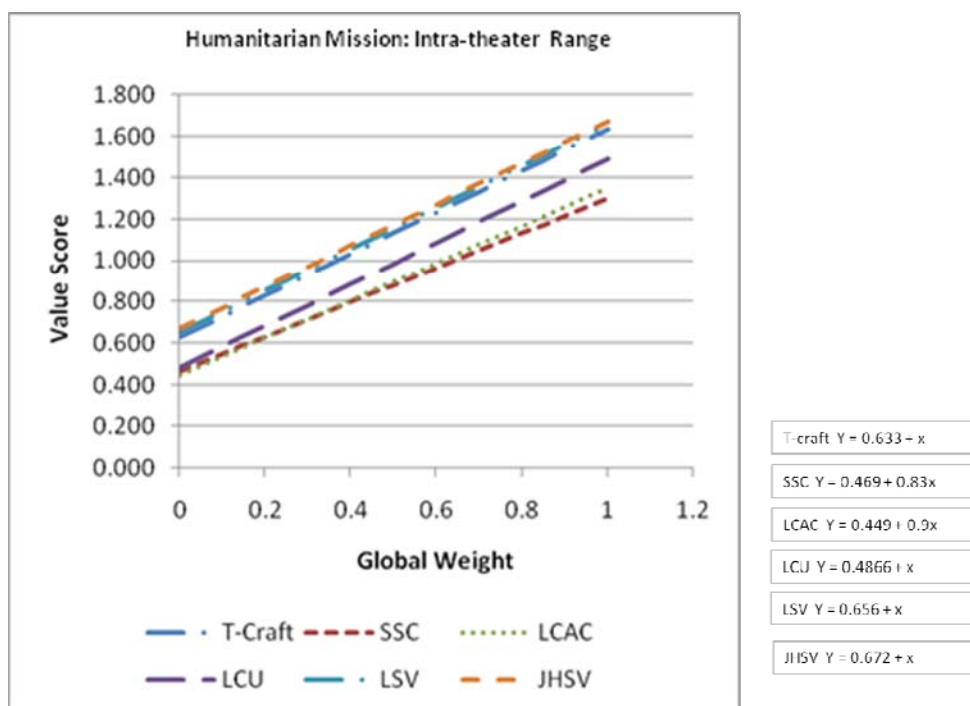


Figure 45. Humanitarian Mission: Intra-theater range

## F. COST VS. VALUE

Both the estimated cost for each of the alternatives, in Chapter IV, and the best performance as represented by the value score for each alternative, in Chapter V has been presented. To properly investigate the alternatives' utility and cost relative to the accomplishment of each mission, the team conducted a cost to utility analysis based upon the two mission profiles previously discussed. As this analysis represents a snapshot for a specific mission, acquisition cost rather than life-cycle cost was used for analysis purposes.

It is important to note that the analysis was conducted as if each mission was conducted with only one type of connector to provide an equal analysis. In actual operations, there might be several types of connectors available and detailed operations research would be conducted to determine the appropriate mix of connectors

## 1. Combat Mission Cost vs. utility

For this analysis, the major combat mission was further refined to add elements of time and cargo requirements. The objective is transporting 13,000 tons in a 10 hour time period. The sea base was assumed to be at the minimum distance from shore of 25 nautical miles, and the connectors would operate at their respective maximum speed.

This analysis is based upon comparing the total acquisition cost of the number of connectors required to meet the transportation requirements of the notional mission as described above against the utility value. This would provide a metric that would allow the team to fairly compare each connector. The first step was to calculate the number of each craft required to move 13,000 tons of combat cargo, from the sea base that is 25 nautical miles from the shore with the craft at max speed in 10 hours. This was done using the total craft capacity for each craft. Figure 46 shows the resultant number of each type of craft to meet the mission requirements. JHSV is zero as it is not suitable for the combat mission per the previous discussion.

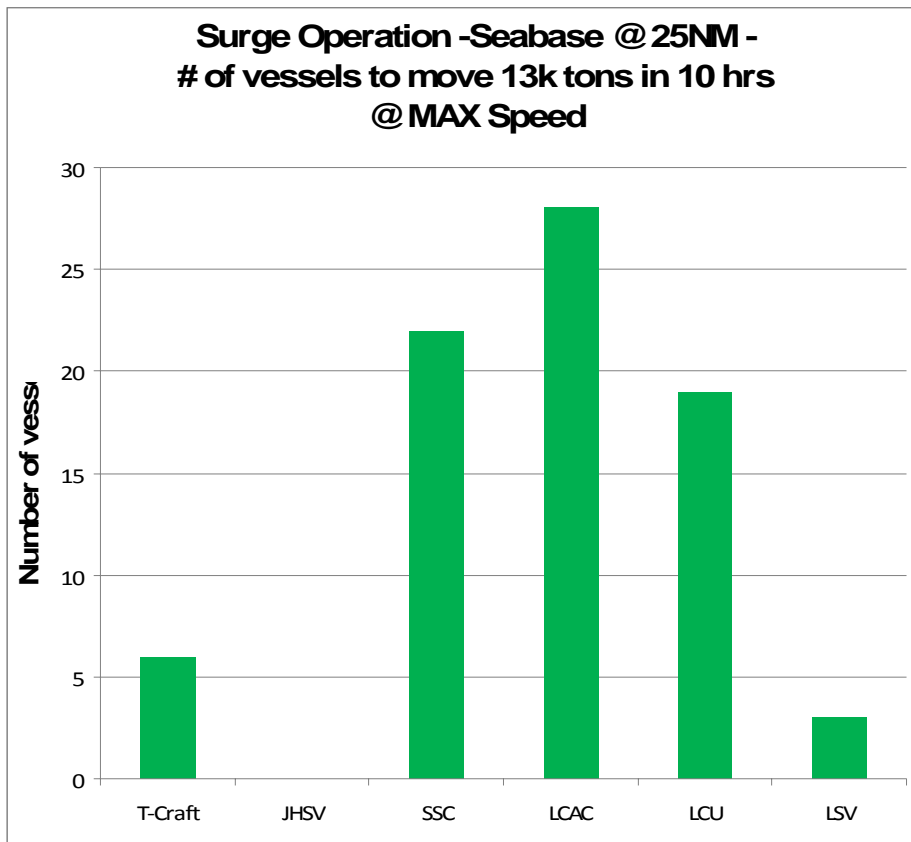


Figure 46. Surge Operation - # of connectors required

Next the acquisition cost of the total number of connectors required to complete this “surge” mission was calculated. This was done by multiplying the number of connectors calculated by the acquisition cost. Finally the total craft acquisition cost is compared to the baseline utility value for each connector, as shown in Figure 47. The line in Figure 47 represents the Pareto Frontier and shows the boundary of the trade space that includes the non-dominated solutions. Two of the five potential solutions for the combat mission are non-dominated: LSV and T-Craft. All other alternatives have higher cost and lower utility than at least one of these two.

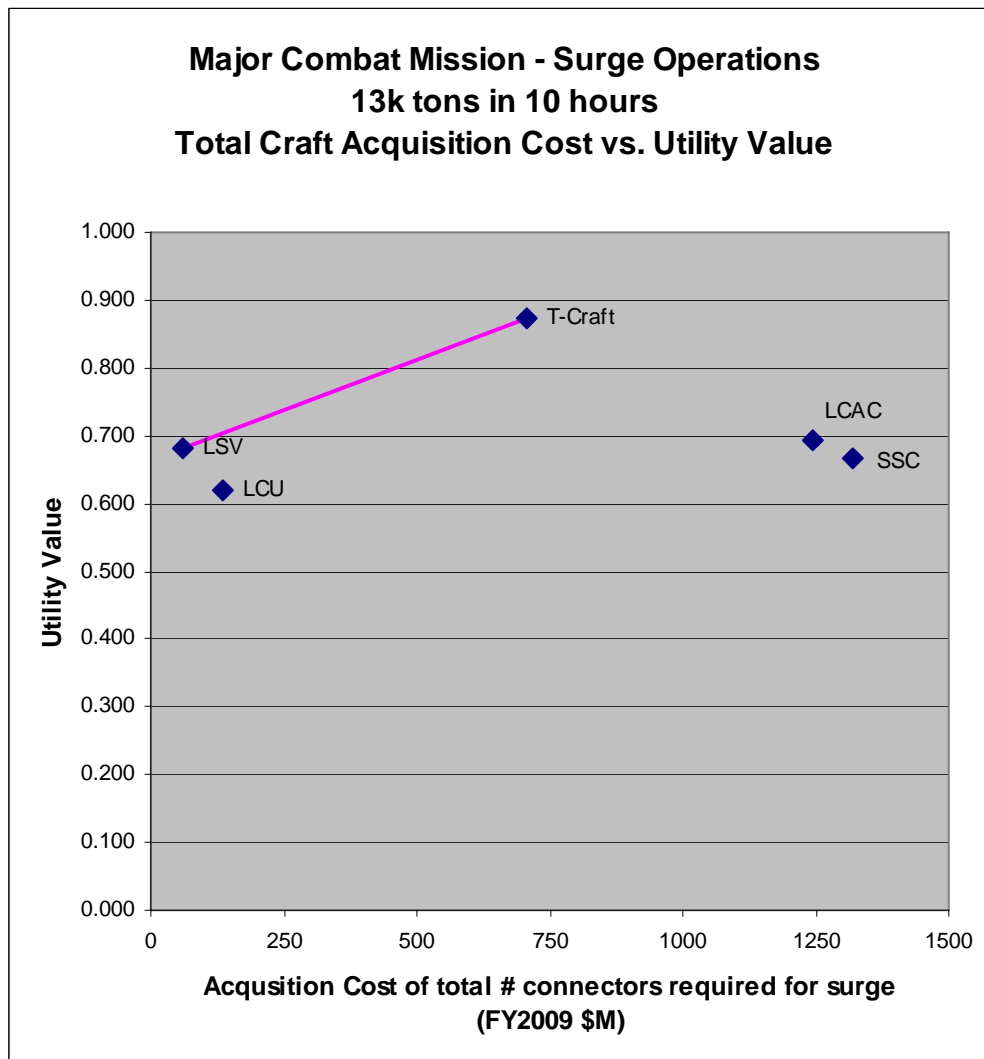


Figure 47. Combat Mission – Cost vs. Utility

Of the non-dominated solutions the T-Craft offers the highest utility with a moderate cost as compared across the alternatives. LSV provides moderate utility at comparatively low cost. The choice between T-craft and LSV depends on whether the 20% increase in utility is worth the major increase in acquisition cost. SSC and LCAC costs are the highest cost due to their relatively small cargo capacity compared to the other platforms and when you look at the number of connectors required, SSC and LCAC can be eliminated from practical consideration (for single platform solutions) due to their moderate utility at very high cost. Likewise, LCU has lower utility and higher cost than LSV so it appears a poor choice

## **2. Humanitarian mission cost vs. utility**

For this analysis, the notional Humanitarian Aid mission was defined as transporting 100,000 tons of supplies in a 48 hour time period. The sea base was assumed to be at the minimum distance from shore, 25 nautical miles, and the connectors would operate at maximum speed.

The approach to the Humanitarian Aid mission analysis is the same as for the combat mission analysis. The first step was to calculate the number of each craft required to move 100,000 tons of humanitarian cargo, from the sea base that is 25 nautical miles from the shore with the craft at max speed in 48 hours. This was done using the total craft capacity for each craft. It is expected that each connector would be full when it travels to the port meaning the vessel was carrying the maximum cargo capacity as specified in the alternatives descriptions. Figure 48 shows the results of the analysis.

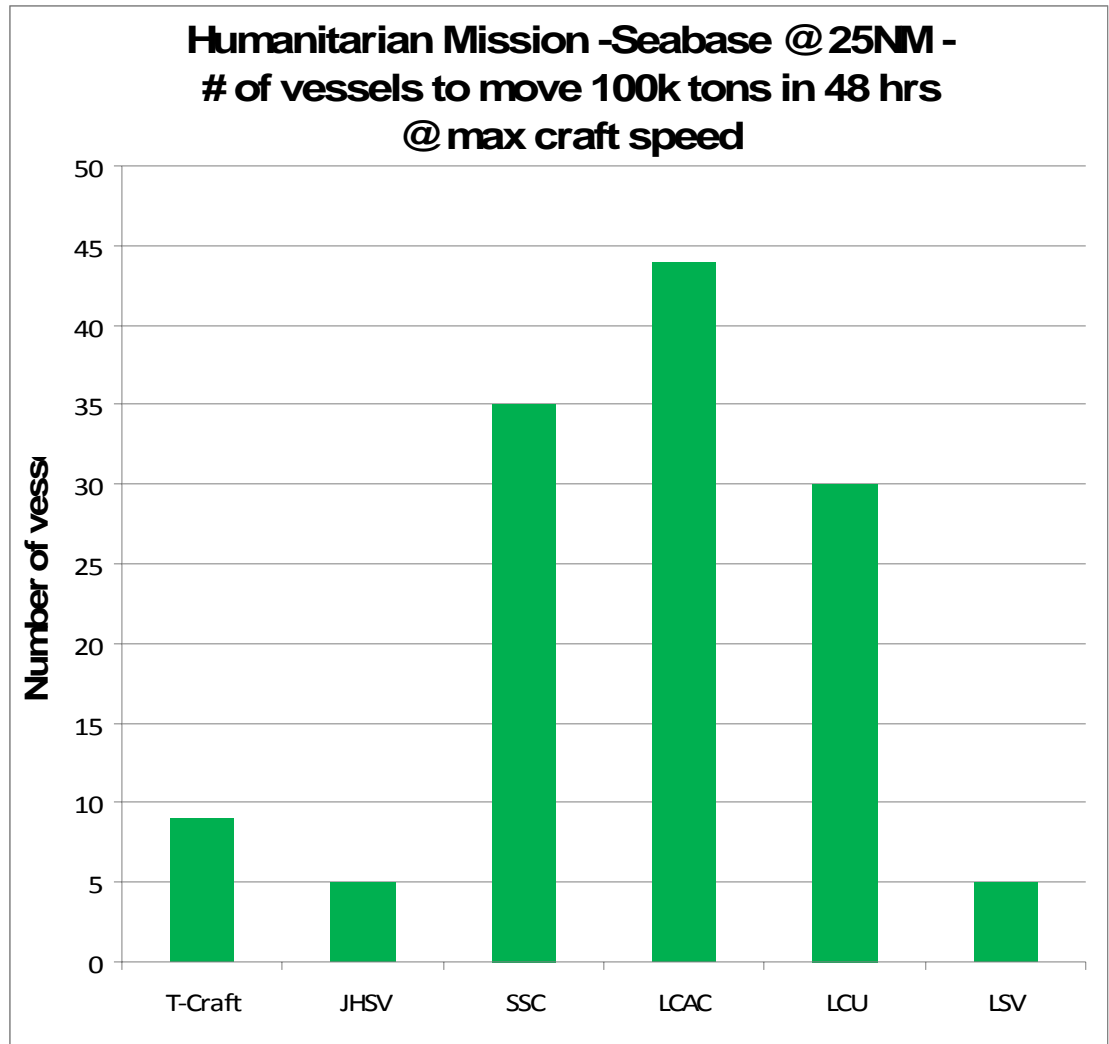


Figure 48. Humanitarian mission: # of connectors required

Next the acquisition cost of the total number of connectors required to complete this humanitarian mission was calculated. This was done by multiplying the number of connectors calculated by the acquisition cost identified in Chapter III. Finally the total craft acquisition cost was compared to the baseline utility value for each connector, as shown in Figure 49. As before, the line represents the Pareto Frontier and shows the non-dominated solutions. Again, two of the six potential systems are non-dominated: LSV and JHSV.

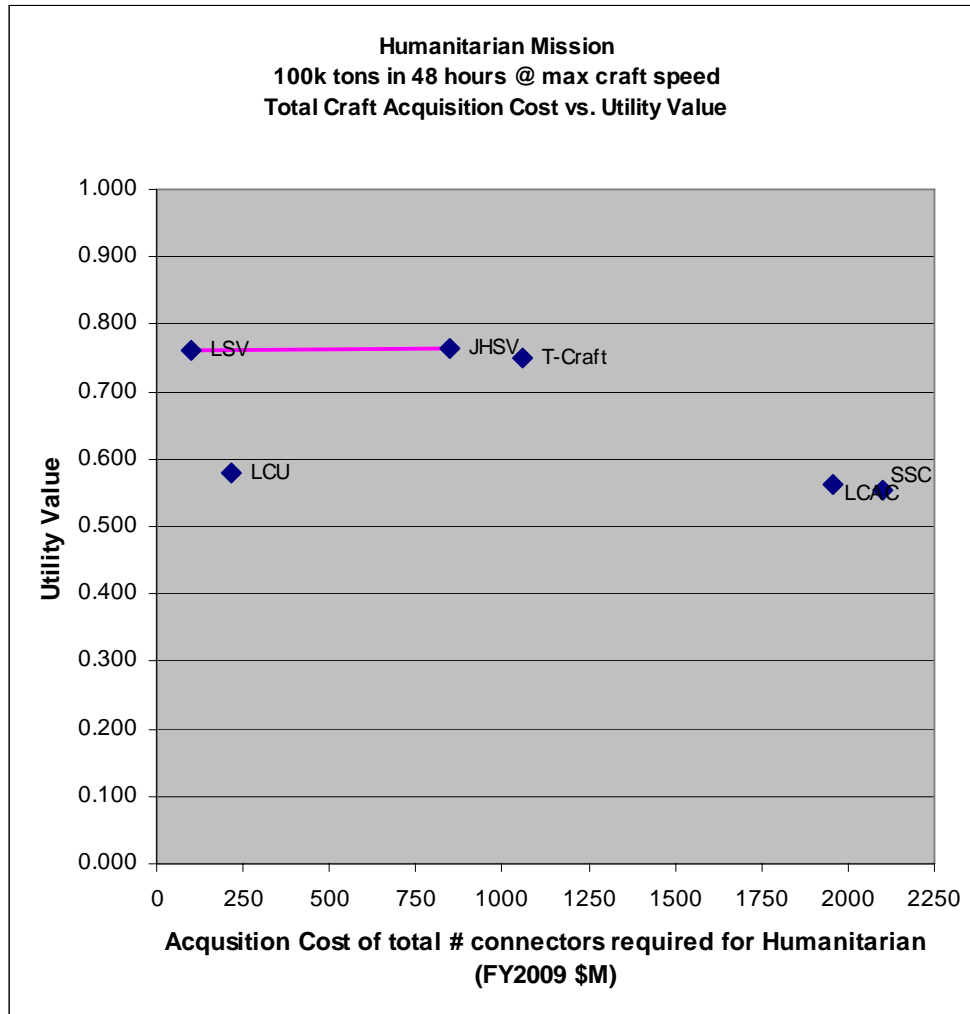


Figure 49. Humanitarian Mission – Cost vs. Utility

Examination of the cost-benefits results for the non-dominated solutions reveals that the JHSV offers the highest utility (though only with a slight increase over LSV and T-Craft) with a moderate comparative cost. LSV again has the lowest cost with a moderate to high utility. As with the combat mission, for single platform solutions, SSC and LCACs have high cost and low utility for the specified mission parameters. The SSC and LCAC can be eliminated from consideration since they are both dominated solutions as can LCU. While T-craft is a dominated solution it is not dominated by much compared to its closest competitor, JHSV.

The LSV, JHSV and T-Craft appear to be the remaining possible choices based on low to moderate cost and good utility. Looking solely at the cost and utility values, T-Craft could be

eliminated from consideration based on the cost-benefit plot with a lower utility but higher cost than JHSV. Based on the cost-benefit analysis for the specified Humanitarian Aid mission parameters the best choice would appear to be the LSV as its utility is about the same as JHSV but its cost is much lower.

## **G. RISK**

The Risk Management Guide for DOD Acquisition defines risk as “Risk is a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints.” (DOD, 2006) The DOD guide essentially defines best practices for risk management and describes the classic 5x5, red, yellow, green risk reporting matrix which is used for risk analysis. The Guide is focused on the traditional three categories of acquisition program risk: cost, schedule and performance.

Blanchard and Fabrycky have a similar but slightly different take on risk. Risk is defined as, “the potential that something will go wrong as a result of one or a series of events.” (Blanchard and Fabrycky, 2006). Risk has four categories: technical, cost, schedule and programmatic. Technical, cost and schedule align well with the traditional DOD risk categories of performance, cost and schedule. Programmatic risk is defined as, “the occurrence of events, imposed on the program/project, which are the result of external influences.” A distinction is made between risks that are inherent to the project versus those that are essentially out of the project’s control (Blanchard and Fabrycky, 2006). The ASE team felt there are risks that are based on factors outside the scope of an ASE platform program so the programmatic risk category are discussed in addition to the usual three categories.

A full risk analysis involves not just identifying risks but also determining priorities of risks by qualifying or quantifying them in terms of the likelihood of their occurrence and the severity of the consequences if they do occur. The risks are frequently mapped to a 5x5 matrix, as pictured in Figure 50 with the seriousness of the risk indicated by the color of the sector in which the risk appears. Green indicates low magnitude of consequence, yellow a moderate magnitude and red a high level of magnitude or significance to the risk. In addition, risk management also involves selecting approaches to mitigate risks to reduce the level of risk, avoid the risk, and transfer the risk or simply to accept the risk as it is.

For this project, the team only identifies some of the possible risks for most of the alternatives. Most of the alternatives either already exist or are in design as programs of record. Their risks, with respect to their documented mission requirements, have already been examined. The team considers possible risk areas for these systems with respect to the ASE mission but does not examine risks for these platforms in detail. Of the alternatives, T-Craft represents the most innovative and new combination of capabilities with a significant potential benefit. As T-Craft is still an S&T project it also entails many risks that the other alternatives have moved beyond through the process of their becoming programs of record. As such, the team selected T-Craft for a more detailed risk analysis.

Team Carderock also utilized the risk methodology in Naval Sea Systems Command Instruction (NAVSEAINST) 5000.8, Naval SYSCOM Risk Management Policy (DON, 2008).

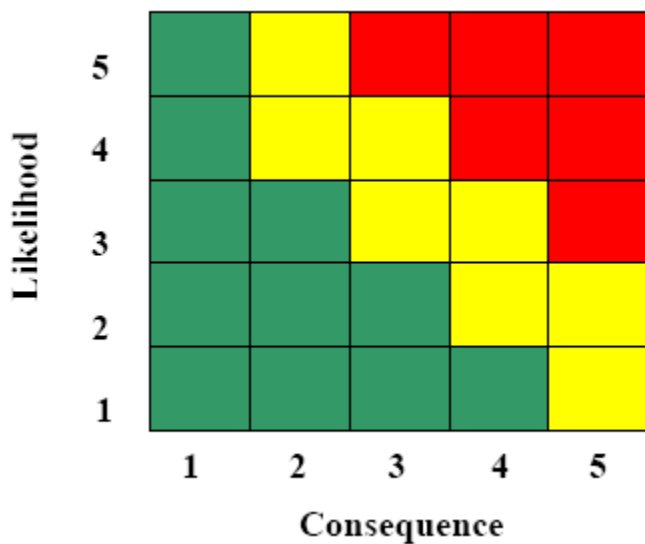


Figure 50. Risk Matrix

## 1. Discussion of Risks – ASE Alternatives

Each of the alternatives considered has risks associated with selecting that alternative as the ASE platform. The following discusses the different alternatives considered and some of the major aspects of their risks. These risks are not comprehensive but represent some of the risks the team felt were most relevant for the various alternatives.

**a. Airlift**

As discussed previously in the report, current airlift capabilities do not meet the requirements laid out for an ASE. The primary shortcoming of current systems is the lack of cargo capacity. There have been recent projects looking at development of heavy lift systems but, those projects have been reorganized and are not well defined at this time. The primary risks of heavy airlift are related to its maturity level. It is simply not mature enough to consider as a viable option at this time

**b. LCU and LSV**

LCU and LSV are covered together as they are similar systems and both are existing systems in inventory. The fact that they are fielded systems in inventory reduces some aspects of their risk as they are known quantities. However, as the decision analysis showed, if the decision criteria developed by the ASE based on stakeholder input are valid then neither the LSV nor LCU fully meet ASE criteria. A key performance risk is their maximum speed. For combat missions speed was considered an important criterion and the LSV and LCU cannot support the high speeds desired by the stakeholders. If those speeds are critical to mission success then this creates a risk to successful mission operations. Another risk of these platforms is that they are aging and may begin to suffer from reduced availability and increased maintenance costs. Additionally, as these platforms age, parts obsolescence may become a risk. Mitigations to this risk might include the SLEP that is planned for both platforms.

**c. JHSV**

The JHSV does not exist in current inventory but, as it is in detailed design it promises to be a potential ASE solution in the near term. While in detailed design it still has not been produced or fielded so there are risks related to the unknowns regarding performance, cost and schedule. Actual field testing may reveal that it does not achieve the projected performance requirements. It may end up costing more than expected. And there may be schedule slippages that impact when the system can be fielded. There are also risks related to the capabilities of the JHSV and its suitability for the ASE mission. JHSV was screened out as a potential alternative

for ASE for combat missions due to its lack of inherent capability to deliver cargo and personnel directly to an unimproved beach. This represents a programmatic risk in the sense that development and fielding of JHSV could utilize resources needed for systems to meet that operational requirement. Likewise, as noted earlier, JHSV is being designed to perform cargo operations in a maximum sea state of 1. While this was not one of the key decision criteria utilized by the team in the decision analysis, it does represent a performance risk in that JHSV may not be fully utilizable in the sea base context.

**d. LCAC and SSC**

The LCAC is the other system, besides LSV and LCU, that exists in current inventory. From an ASE standpoint there are several performance risks, with the most notable being its lack of ability to self deploy and its small cargo capacity. LCAC also carries significant cost risk as there are issues with availability and maintenance costs for the platform. These issues are some of the drivers for the slated replacement for LCACs, the SSC. The SSC is still in design and as such has similar risks to the JHSV due to the uncertainties involved in a system that has not been produced and field tested. However, the SSC is being designed to address the availability and cost issues found with the LCAC. While the SSC has a slightly higher cargo capacity and speed compared to the LCAC it has lower range and still represents performance risks from an ASE requirements perspective.

**e. T-Craft**

As described in the alternatives section, the T-Craft is an innovative concept being explored by ONR. The T-Craft concept calls for an innovative collection of features designed to provide “game changing” capability for enabling seabasing. A key concept is the ability to transform between catamaran, SES and ACV modes, hence its name, the Transformable-Craft or T-Craft. Such game changing capability obviously comes with risk. The risks associated with T-Craft are considered below.

**Performance Risk**

The risks related to T-Craft in the three primary areas of interest (cost, schedule and performance) need to be identified. Most programmatic risks are generally applicable to all alternatives and are discussed separately after the T-Craft discussion. As T-Craft is an R&D effort that involves development of new technologies, much of the performance risk associated

with T-Craft can be captured by considering the technology risks associated with the development. ONR identified key technology challenges in a status brief discussing the T-Craft project. (ONR, 2007) These technical challenges were:

1. Transition of Propulsion systems from in-water to out-of-water
2. Variable/retractable skirt geometry
3. High strength, lightweight, long-wear materials
4. Active ride control systems
5. Human system integration
6. Vehicle transfer at the sea base

For the purpose of developing risk matrices the team used the six technical challenge areas for simplicity and time's sake. Figure 51 shows a risk matrix for performance issues for T-Craft, followed by the rationale for the risk levels. Risk values were assessed using the engineering judgment of the team members.

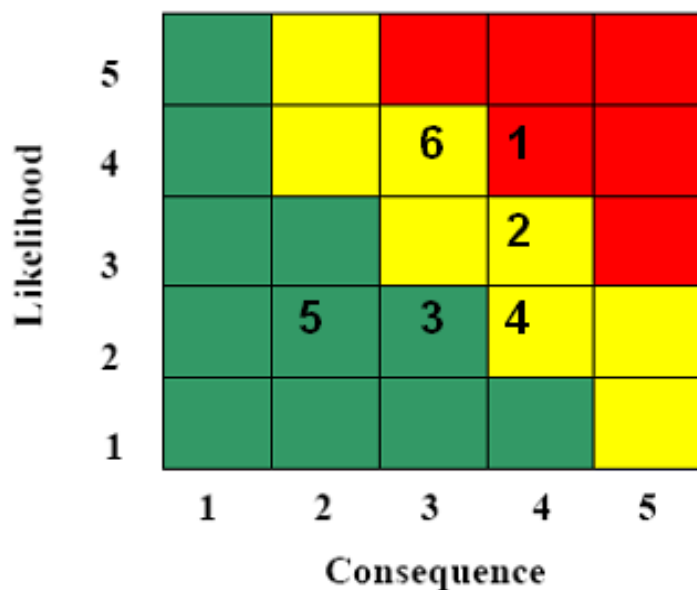


Figure 51. T-Craft Performance Risk Matrix

To populate the matrix, each risk area had to be assigned a likelihood and consequence level. The rationale for each technical risk area follows.

### **1 Transition of Propulsion systems from in-water to out-of-water**

The ability to transition between travel modes is essential to the ability of T-Craft to perform its role. It is what makes it the *transformable* craft. The consequences of a failure in this area are high so the team ranked this risk area with a consequence level of 4. The complexity of this technical area is also high which is why the team ranked it with a likelihood level of 4.

### **2. Variable/retractable skirt geometry**

Similar to the previous risk area, the ability to deploy and retracts skirts is essential to the T-Craft mission. As such it was also given a consequence level of 4. The team felt that this technical area is somewhat less complicated than the propulsion area so the likelihood was given a level of 3.

### **3. High strength, lightweight, long-wear materials**

Utilization of high strength, lightweight, long-wear materials is important to achieving some of the technical goals for the T-Craft. However, there is a great deal of work going on in this area that the T-Craft project should be able to leverage. The LCS and JHSV programs are utilizing aluminum in the construction of the vessel. ONR is doing significant research on composites as are many other organizations and a several major Navy programs such as DDG 1000 and LPD 17 have made use of composite materials. Since the impact to the project is significant but not overly so the team gave this risk area a consequence level of 3. Due to the large amount of other work in this area that could be leveraged the team gave this risk area a likelihood of 2.

### **4. Active ride control systems**

Active ride control systems are used on many different platforms today and play an important role in safety of on-board personnel and cargo. If a workable active ride control system cannot be developed it will significantly impact the performance of the T-Craft. For this reason the team scored this risk area a 4 for consequences. However, as mentioned previously, active ride control systems do exist today. While the complex nature of the T-Craft increases the risk to

developing a system to meet this need for this platform this is still a fairly well worked technical area. As such the team gave a score of 2 for likelihood.

## **5. Human system integration**

Human System Integration (HSI) is an area that has been getting increasing attention in the DOD acquisition realm. It is an important area that impacts performance and cost. The primary reason given for improved HSI for T-Craft is to meet the reduced manning goals. While important, this is not a critical factor from a performance perspective. There has also been considerable work done in the area of improved HSI for reduced manning and other purposes. As such the team gave this risk area a consequence and likelihood level of 2.

## **6. Vehicle transfer at the sea base**

The ability to load and off-load cargo at the sea base is an essential attribute required to make T-Craft useful as a sea base enabler. From the ONR material it appears ONR is considering special equipment to move vehicles from the sea base to the T-Craft and vice versa. As T-Craft should support RO/RO capability, which is implied by the vehicle transfer capability itself, it seems that much transfer of vehicles could take place under their own power, rather than being moved by another system. While there may be some vehicles that require assistance in moving for the sea base environment, since many could likely move under their own power the team gave a consequence level of 3. Given the weight and awkward geometry of many military vessels, a system designed to move these vehicles in an at sea environment may be challenging. As such the team scored this risk a 4 for likelihood.

Now that risks have been identified and prioritized, risk mitigation should be considered. In a sense the whole T-Craft effort, as an R&D effort, is a risk mitigation effort. A major purpose for R&D, at least from a DOD acquisition perspective, is to mitigate operational risks. In addition, these detailed technical efforts require significant technical expertise to determine appropriate mitigations. What can be said is that ONR should understand what the risks are and should have an “off ramp” for each major technical risk that has a consequence or likelihood of 3 or higher. ONR should have an understanding of what alternatives are available for each technical area if there is a failure to achieve the developmental goals in that area. While the resulting capability might not be as good as with a successful development it may still provide value from an operational perspective.

## Cost Risk

The team was not able to identify many individual cost risks related to T-Craft. T-Craft is an R&D project and R&D is inherently risky. In fact, R&D differs significantly from acquisition in that R&D tends to be risk embracing, at least to some degree, whereas acquisition tends to be risk averse. This dichotomy is one contributing factor leading to what is popularly known as the “valley of death” which represents the challenge of transitioning from R&D to acquisition. The key cost risk is that the T-Craft project may not be able to achieve all of its goals within budget due to the many unknowns involved in performing R&D. Treating cost as an individual risk the team would assign it a consequence of 2 and likelihood of 4 as shown in Figure 52. As an R&D effort, it is not uncommon to require additional funds to achieve the desired results. However, the impact of a cost overrun for an R&D project is not as dramatic as for an acquisition project. The only mitigations for cost risk the team can offer are to use some of the many project management and systems engineering tools and methods available. Earned Value Management (EVM) is one example. While not as useful for R&D projects as for acquisition, since phase 2 of the T-Craft project will be of substantial expense, utilizing some form of EVM may help identify both cost and schedule issues earlier when they are more likely to be mitigated. Prioritizing the different tasks within the project may also help avoid additional costs due to churn if there is a budget issue and something needs to be cut.

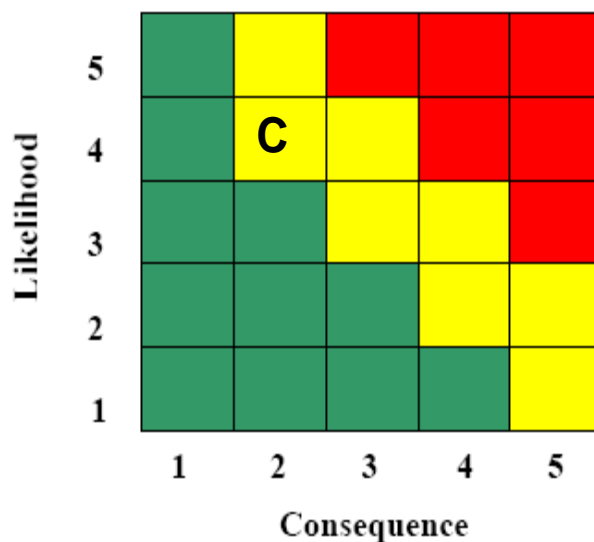


Figure 52. T-Craft Risk Matrix

## Schedule Risk

As with cost, it is difficult to identify specific schedule risks for the T-Craft project. As an R&D effort it has more inherent flexibility with regard to schedule than does an acquisition program. This does not mean attention should not be given to staying on schedule. The main schedule risk for T-Craft again centers on its nature as an R&D effort and the inherent risk involved in R&D. This makes a schedule overrun of some sort likely unless significant slack is built into the schedule. As the ultimate goal of the T-Craft project is to meet an operational need of enabling the sea base, schedule may be somewhat more significant than cost as there may be operational schedules for when such a capability would be needed. As discussed later on it is unclear if such schedules exist but the team scored schedule risk as a 3 for consequence. Similar to cost, R&D projects frequently run over schedule so a likelihood of 4 is suggested as shown in Figure 53. The mitigations suggested for cost are equally applicable to schedule.

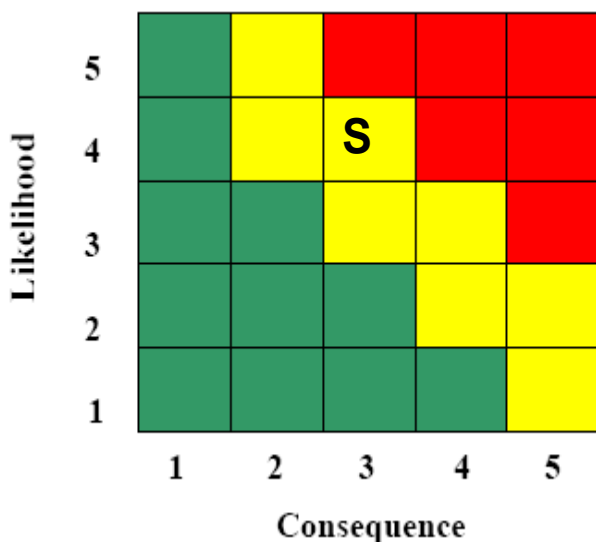


Figure 53. T-Craft Schedule Risk Matrix

If an average is computed for the performance risks for T-Craft, an overall performance risk level for the system can be estimated as a likelihood of 2.83. Likewise the average consequence value is 3.33. Using these values an overall risk matrix for T-Craft for cost (C), schedule (S) and performance (P) can be generated as shown in Figure 54.

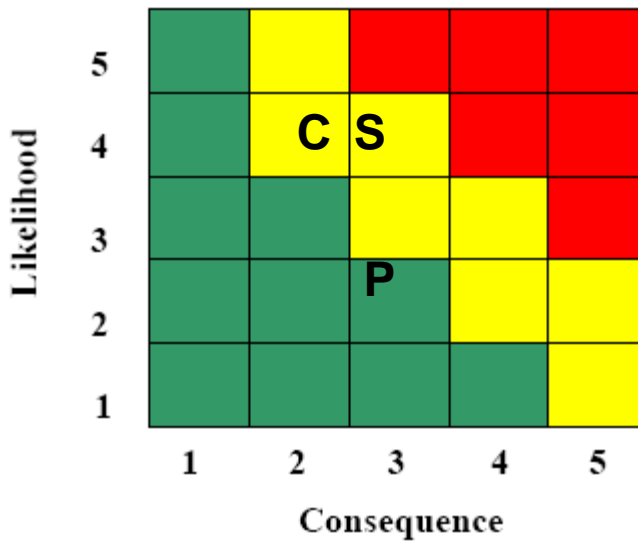


Figure 54. T-Craft Overall Risk Matrix

### Programmatic Risk

There is significant programmatic risk for T-Craft and for all ASE alternatives. Again, for the purposes of this effort, per Blanchard and Fabrycky, programmatic risk refers to risks based on outside influences (Blanchard and Fabrycky, 2006). There are many outside elements that will influence the viability and value of an ASE system. These include:

- Seabasing doctrine – seabasing has been identified in many high level documents as being an important element of our military strategy. This could change. Likewise, there are many aspects of seabasing that influence requirements for an ASE such as the range at which the sea base is expected to operate. ASE requirements will change based on how these doctrines are established.
- Sea base composition – A sea base is a flexible entity and may be composed of a variety of assets. There are a number of propositions regarding new platforms and the composition of a sea base. ASE requirements could change depending on the dominant approach to sea base composition.
- Seabasing technologies – As stated earlier in the report, this project assumed that many of the technologies and systems required to make the sea base work would exist when an

ASE capability was ready for fielding. This may not be the case. For example, if methods for ship to ship transfer in high sea states are not adequately worked out this will certainly impact the effective capability of an ASE.

The team did not attempt to individually score programmatic risks. There are undoubtedly others beyond what is mentioned above. It is difficult to prognosticate on where such high level efforts will end up. The team felt that the likelihood of there being some change or further definition regarding doctrine or seabasing technologies was somewhat likely so it was given a score of 3 for likelihood. The impact is highly dependent on the specific change. It could be highly significant or very minor. As such the team went for an average with a score of 3 for consequence. This is represented in Figure 55. It is difficult to mitigate these kinds of risks. The primary way is to be involved. Engage with the operational community regarding seabasing needs and plans. Stay on top of what is happening with regard to doctrine and technology development. And, of course, utilize good program management and systems engineering practices that allow for an understanding of where an effort is and the impacts of changes to it.

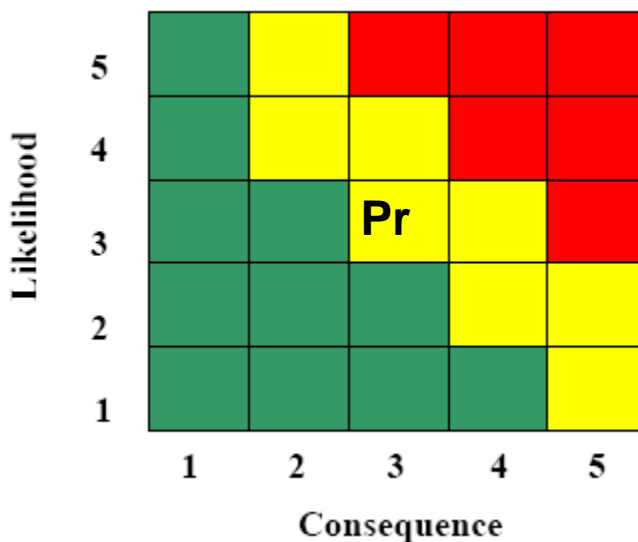


Figure 55. ASE Project Risk Matrix

## **VI SUMMARY**

### **A. RECOMMENDATIONS**

Throughout this entire capstone project, the team has been primarily focused on the operational requirements collection, analysis and validation. The functional analysis, based on the operational requirements, consideration of possible alternatives compared to the collected requirements, “racking and stacking” of the alternatives based on stakeholder priorities and selection and documentation of alternatives.

Primarily through a DOD literature search and review process, the team developed a list of requirements for each of the four operational scenarios chosen as our foci for the project. These requirements were then presented to the key stakeholders that were identified during the scoping portion of this effort. Following the review by the major stakeholders, the team focused on the requirements that were developed as validated requirements. It is important to note that there are some fundamental discrepancies in the needs and desires of the various key stakeholders; one critical discrepancy was whether or not the ASE needed to possess a forcible entry capability. The JHSV, LCAC and other logistics platforms are not designed to operate in certain threat environments. During a meeting with USMC it was indicated that there is a capability gap in amphibious warfare, from their standpoint, and there is a desire for the T-Craft to have some offensive capabilities and the ability to perform forcible entry operations.

Based on the research and analysis conducted by this project team, the recommended solutions regarding advanced sea base enablers are shown in Table 25:

Table 25. Recommended Sea Base Enablers

Operational requirements	Recommended ASE
For operations and quick response actions that require feet dry, beach deployment of personnel and equipment such as a major combat operation, the T-Craft appears to have the best capability for the cost. Although the LCAC, LSV, LCU-2000 and SSC all have or will have the capability to traverse the surf zone and deposit their cargo feet dry, from a performance perspective, the T-Craft was shown to have the best combination of speed, range, and cargo capacity. The recommendation is based on the performance and cost analyses performed. T-Craft also comes with significant risks that will have to be factored in to any decision.	T-Craft
For operations such as a Humanitarian Aid mission that allow for the use of a port facility, an austere port or a Quay wall (large wall, usually masonry, bordering a body of water) the LSV is the best capability for the cost. Additional, the LSV can also be used on a beach.	LSV
The cost analysis of the two operational scenarios, using data from tables 17 & 18, indicates that the ASE of choice would be the LSV for both operational scenarios if cost were the dominant decision factor. The LSV is relatively inexpensive to build, and maintain. The next closest ASE in total cost per system was the LCU which was approximately \$80M more in the combat mission and nearly \$120 M more in the humanitarian aid scenario.	LSV
The best existing operational alternative for humanitarian or combat operations today, based on the decision analysis, is the LSV. As the alternatives still in developmental stages, such as the T-Craft and the JHSV become operational, operational needs could be reassessed to factor in the new capabilities.	LSV
The T-Craft has been show to have utility in both the major combat operation and the humanitarian aid scenarios. This team recommends that ONR continue to fund the development of the T-Craft and support the ongoing technology insertion efforts to bring the conceptual designs into operational reality.	T-Craft

## **B. KEY ASSUMPTIONS**

During the evolution of the Capstone project, the team made numerous key assumptions to help maintain the proper project scope and bounds to ensure that the project effort was achievable in the time frame available. The initial assumption made by the team is that seabasing is the viable approach. From this base assumption several alternatives were developed and subsequent analysis was conducted. Next, the team developed several further assumptions based on the nature of seabasing. Currently the distance from shore for a sea base is not a well defined parameter and to complicate matters more for the team the distance from shore for a sea base has significant impact on how fuel is supplied to the beach. The current fuel pipe capability for piping fuel from container ships to the shore does not support sea bases over the horizon. This will impact the ability of the connectors to move higher tonnages of cargo as there will be a need for movement of fuel ashore as well as personnel and equipment. It is important to note that our analysis did not consider the negative impact of moving further from shore due to the additional requirement to move fuel; it only analyzed the increased distance from a transit time impact. For our analysis, the further the sea base was from shore the better, within a reasonable amount of transit time. This was based on the advantages obtained in maneuverability and safety of sea base assets.

The next key assumption regarding the sea base had to do with the many technical obstacles that must be overcome to fully enable the sea base. Naval Sea Systems Command is currently developing a robust transfer capability to move personnel and equipment quickly and more efficiently around the sea base. For the analyses conducted in this study, the specific requirements for moving personnel and equipment to the various connectors are considered available and supportable in sea state 3 and 4 respectively. The assumption developed by the team is that the cargo can be efficiently loaded onto the connectors at the sea base. The prime focus of the analysis was on the movement of the ASE to the sea base, and once loaded with cargo, its movement to their respective points of debarkation.

In regards to the different connectors that were analyzed by the team, we did not consider the detailed engineering or system design of those connectors due to time constraints. The assumption is that the technical designs required to support the operational concepts will be met and the connectors will perform as defined in detailed system specifications and key

performance parameters (KPP's). To further delve into specific technical constraints and design characteristics of the sea base or connectors would have broadened the scope beyond what was feasible to accomplish with the time and resources available.

### **C. LIMITATIONS**

The initial concept the team developed was centered on the sea base supporting four different operational scenarios based on summarizing mission sets based on a detailed analysis of many other operational scenarios portrayed on DOD doctrine. The four options represented a reasonable set of scenarios for assessing ASE value but were not representative of the ROMO. Due to the limitations imposed on the effort, the team did not thoroughly investigate each of the four major operational scenarios. Therefore the team prioritized efforts to examine MCO and Humanitarian Aid as the most and least stressing operational requirements, respectively. The other two operational scenarios, Police Action and Disaster Relief, had significant overlapping and redundant operational requirements which led the team down the path of eliminating them from the initial analysis effort.

In general, the focus of the effort was on the Concept Development stage of acquisition and a simplified AOA culminating in a recommended approach for ASE. The team considered alternatives from a high level functional perspective. The team did not perform detailed engineering analyses, provide a recommended naval architecture or any other detailed engineering work. However, the team collected many sources of available information on potential alternatives for ASE and, with basic checks for achievability, has largely assumed that the information collected regarding the various systems is reliable.

The team had several influencing factors that also produced limitations to our analysis. The Analysis was limited to current DOD Programs of Record (POR) and existing design efforts. The team did not attempt to develop, design or create a new ASE. Instead as previously stated, the team collected available information on existing and planned connectors and then compared them against each other from an operational and functional requirements standpoint. The team was supported throughout the project by various organizations and people throughout the DOD community.

A reoccurring premise throughout this report is the inconsistencies and conflicting requirements provided by the different stakeholders. Due to the limited time associated with the project, full verification and validation of the individual technical requirements could not be conducted. As will be explained in the recommendations section, one of the primary recommendations that should be addressed is the inconsistencies in the desired capabilities between the individual major stakeholders.

#### **D. FUTURE STUDIES (THE WAY AHEAD)**

The team has identified numerous areas where follow-on studies and additional research can be performed to further evaluate the need for and value of an ASE. This list of potential future efforts is not all encompassing, however it does provide numerous areas where additional information can be collected and evaluated to improve and further strengthen the overall recommendations regarding an ASE. The recommendations for future efforts are organized according to the major efforts conducted as part of this study.

##### **1. Overview/Seabasing Background**

To be able to fully assess the capabilities and need for an ASE, a formal AOA will need to be conducted. As part of an AOA, detailed engineering analysis of the various capabilities will need to be evaluated to determine the feasibility of the Transformable Craft as an operational asset.

A primary key assumption that was made was on the validity of the sea base. Future studies on the need and utility of the sea base will have significant impacts on the decision analysis performed. An analysis of not only the feasibility and utility of the sea base but also that of the minimum and maximum distance from shore should be conducted to establish DOD policy and document clear requirements that would influence the nature of an ASE.

##### **2. Formulation**

As documented throughout the report, a recurring theme was the inconsistencies and conflicting requirements provided by the different major DOD stakeholders. The team recommends, as part of the future efforts, a specific list of formal requirements must be established that supports each of the individual stakeholders and that is formally documented so it can be used in analyzing potential solutions to those requirements. Once a more complete list of requirements has been established then the ASE analyses can be revisited and refined.

Future efforts should entail an analysis of all functions of the sea base. The analysis conducted was primarily on the functional capability of an ASE as it departs the sea base following equipment load out. The analysis did not cover self deployment of the ASE to the sea base. Additionally, an analysis of the complete range of military operations which would include the remaining two operational scenarios (Police Action and Disaster Relief) identified by the team should be conducted. Expanding the mission analysis to more comprehensively address the ROMO would be worthwhile. As part of the future studies, careful consideration of the non-functional requirements must be included to ensure a fully functional and usable system.

### **3. Analysis**

#### **a. Modeling and Simulation**

M&S represents an area where considerably more effort could be expended with significant payoff. Recommended future studies include completing the envisioned studies that this team did not have the resources to complete. Detailed models for all of the possible alternatives need to be constructed allowing for a dynamic assessment of the Process Cargo (Assemble) and Transport Cargo (Employ) functionality of an ASE. This will allow much more refined value assessment of the various alternatives individually and in combination. The models could also be expanded beyond the Assemble and Employ functions to consider Reconstitution (also part of Transport Cargo) and Close (Deploy ASE) functionality.

Due to time limitations, this modeling and simulation study was unable to create functional descriptions and their corresponding discrete event simulations for any of the alternative technologies discussed in this report. Therefore, these initial simulation runs and corresponding analysis serve as a proof-of-principle of this simulation methodology. We believe that future research on sea base enablers needs to include a more robust usage of system simulation, examining and comparing each of the proposed alternatives in a challenging, dynamic environment.

#### **b. Cost Analysis**

Cost estimation is a field of its own and a major undertaking in its own right. The cost analysis performed as part of this study was very limited and high level. More complete and

validated cost data is needed for the existing platforms and systems still in the design phase. In particular, better data for O&M and NRE costs are needed. These costs should be collected and folded into a refined ASE cost analysis.

The cost analysis was accomplished using an analogous cost estimate and numerous variables from the different alternatives, then assessing the best matching variables and computing the costs per parameter on the alternative to estimate the T-Craft cost. As more formal acquisition and LCCP costs for the T-Craft are established, the analysis will need to be reassessed to determine if any changes in costs has an impact on the overall evaluation.

Based on the current financial crisis and continuing Federal Government loan programs, a zero discount was used from FY09 to FY11. As the various stimulus package programs are halted, a review of historical and future cost models would provide a better determination if some level of discount factor should be applied to the FY09 to FY11 cost estimates.

An assumption was made that all NRE costs would start in FY11. This is highly unlikely as the T-Craft and SSC may not have any significant R&D expenditures until the FY15 timeframe. Therefore, the LCCP estimates will need to be updated to adjust for changes in fiscal year planned expenditures.

#### **4. Interpretation**

To fully assess appropriate ASE alternatives a more comprehensive collection of parameters should be used, hopefully based on better validated requirements for seabasing and an ASE capability, for feasibility screening and decision analysis. As part of the decision analysis, the team selected six requirements based on stakeholder prioritization and subject matter expertise input to analyze each alternative. Future efforts will need to examine a more comprehensive set of validated operational and technical requirements to determine the best option available.

As part of the decision analysis, beachability was established as a binary value. An improved method for future decision analysis and value assignment would be to change from two levels to three levels of requirements analysis for beachability. Three recommended levels would be:

- Not beachable – platform requires a port facility of some sort or external resources to deliver cargo to an unimproved beach.
- Beachable - equipment can be deployed feet dry via a ramp while the vessel remains in the water.
- Fully amphibious - allows for full access to an unimproved beach and potential inland deployment of personnel and equipment.

This further refinement would be an improvement as it recognizes the additional value achieved by having a fully amphibious capability. The improved access to the land site as well as the ability to traverse sand bars and mud flats afforded by fully amphibious capability should be captured as part of the analysis.

As noted previously, following the completion of the decision analysis, the team determined that instead of an absolute value for crew size, it would be more appropriate to utilize a ratio of crew size to the cargo capacity of the vessel or some similar ratio. This would eliminate some of the bias against larger vessels that generally have higher crew requirements but also generally have better cargo capacity. As part of future studies, a ratio of crew to cargo capacity should be considered as part of the decision analysis.

Future analyses should broaden more beyond individual craft to look at force structure composition that includes ASEs. With the exception of the limited M&S analysis and cost-benefit analysis, the bulk of the analysis performed as part of this study looked at individual ASE alternatives by themselves. To fully assess the impact of an ASE platform on seabasing capability will require a more comprehensive analysis of collections of potential ASEs in concert with other sea base assets.

As the various vessels and alternatives mature and are brought into service or upgraded, the detailed value analysis should be repeated using real world performance measurements to ensure that this analysis model remains consistent. For the decision analysis, the team sees both short and long term efforts that can be undertaken:

**a. Short Term**

Analysis needs to be done of how soon seabasing needs to happen based on DOD Guidance and Policy. If there is a requirement for seabasing to be operational in the near term

then a decision analysis should be performed to factor in time to realize a viable solution. Also, the total amount of cargo an ASE needs to move needs to be revalidated. Analysis of whether the design objective should be the sustainment cargo or the surge cargo needs further study. If the amount of cargo is more than the 1000 ton of sustainment cargo in a 10 hour window and is closer to the 13,000 ton surge of moving a Stryker Brigade Combat Team in a ten hour window, then the Decision Analysis needs to be weighted accordingly. Based on a 25 nautical miles range, transit time only at 40 knots and not including loading and un-loading times, 6 T-Craft can move 13,000 tons in a 10 hour window. Based on a 25 nautical mile range, transit time only at 12 knots and not including loading and un-loading times, 3 LSV's can move 13,000 tons in a 10 hour window. 7 LSV's can move the entire Stryker Brigade Combat Team 13,000 ton surge in one movement.

It is also recommended that the requirements for vessel speed in the near term need to be reexamined. In the 25 nautical mile scenario outlined above, the T-Crafts objective speed of 40 knots allows it to reach shore in 38 minutes. The slower 12 knot speed of the LSV takes 125 minutes over the same distance. If a phased approach to seabasing that finds it permissible in the near term to allow lower speeds and phases in higher speeds in the long term, a cost/benefit analysis may show that there are viable existing material solutions for near term, albeit slower, sea base enablers.

**b. Long Term**

Beyond validation of the total amount of cargo, the required integrated combat systems needs to be examined. A detailed threat analysis needs to be performed that specifically addresses the ASE operating away from its protecting escorts in the shallow littorals and beached. The value of ballistic shielding of critical components and crew areas needs to be analyzed, as well as need for self defense and countermeasures.

Sustainability, Maintainability, and Lifecycle Cost Analysis of the alternatives will also need to be analyzed as part of the decision analysis. Half of the alternatives used in this report are not currently fielded systems, so a comparison of the non-functional requirements must be performed as part of any future decision analysis to better understand the overall costs beyond system procurement.

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## APPENDIX A – DOCUMENTATION REVIEW

The following documents were reviewed by the ASE team during the initial phase of the project.

Army Transportation FAA (PIA Updated) - 14 Sep 07
Army Watercraft FNA (PIA Updated) - 14 Sep 07
Army Watercraft FSA (PIA Approved) - 13 Nov 07
Army Watercraft Master Plan - April 08
Army Watercraft Requirements (010209rev1) _ OLD.ppt
Army Watercraft Requirements (030209) (NXPowerLite)
Army_Perspective_on_seabasing_- _31July06
ASNE Day 2006 Paper Operational Logistics in the Future Sea Force
Defense Science Board Task Force on Seabasing
Identifying Requirements for seabasing Assets
JLOTS (Joint Logistics Over-the-Shore) joint pub 4-01.6- 5 Aug 05
NATO Paper
Naval Transitions Roadmap 2003 - Assured Access and Power Projection from the Sea
Naval Transitions Roadmap 2003 - Power and Access from the Sea
Naval_Operations_Concept_2006
Sea base Connector Transformable
Seabasing - Ensuring Joint Force Access from the Sea
Seabasing: Joint Integrating Concept
Seabasing _MIT_Concept Design Solutions
Seabasing 2015 - Concept Design Solutions.pdf
Seabasing Book
Sea_Basing_Enablers_INP_Cooper
T-Craft Brief HSS-AP AO Group 29Oct08_Final
T-Craft Concepts Technical Foundation
TRADOC_White_Paper_Joint_seabasing
United States Navy_ Sea Power 21

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## APPENDIX B – M & S DATA

### Extend model Output Data:

#### LCAC Unload Times

LCAC Number	Unload Time
1	3.966
2	3.966
3	3.966
4	5.216
5	5.216
6	5.216
7	6.466
8	6.466
9	6.466
10	7.716
11	7.716
12	7.716
13	8.966
14	8.966
15	8.966
16	10.216
17	10.216
18	10.216
19	11.466
20	11.466
21	11.466
22	12.716
23	12.716
24	12.716

25	13.966
26	13.966
27	13.966
28	15.355
29	15.355
30	15.355
31	17.834
32	17.834
33	17.834
34	20.271
35	20.271
36	20.271
37	21.808
38	21.808
39	21.808
40	23.058
41	23.058
42	23.058
43	24.308
44	24.308
45	24.308
46	25.558
47	25.558
48	25.558
49	26.808
50	26.808
51	26.808
52	28.058
53	28.058
54	28.058
55	29.308
56	29.308

57	29.308
58	31.530
59	31.530
60	31.530
61	33.403
62	33.403
63	33.403
64	35.864
65	35.864
66	35.864
67	38.505
68	38.505
69	38.505
70	40.367
71	40.367
72	40.367
73	41.873
74	41.873
75	41.873
76	43.123
77	43.123
78	43.123
79	44.373
80	44.373
81	44.373
82	45.623
83	45.623
84	45.623
85	47.711
86	47.711
87	47.711
88	49.364

89	49.364
90	49.364
91	51.250
92	51.250
93	51.250
94	53.885
95	53.885
96	53.885
97	55.318
98	55.318
99	55.318

#### Vehicle Ramp Transit Completion Times

Vehicle Number	Completion Time
1	1.180
2	1.230
3	1.280
4	1.330
5	1.380
6	1.430
7	1.480
8	1.530
9	1.663
10	1.713
11	1.763
12	1.813
13	1.863
14	1.913
15	1.963

Vehicle Number	Completion Time
16	2.013
17	2.063
18	2.113
19	2.163
20	2.213
21	2.363
22	2.413
23	2.463
24	2.513
25	2.563
26	2.880
27	2.930
28	2.980
29	3.030
30	3.080
31	3.402
32	3.452
33	3.502
34	3.552
35	3.602
36	3.939
37	3.989
38	4.039
39	4.089
40	4.139
41	4.189
42	4.239
43	4.408
44	4.458
45	4.508
46	4.558

Vehicle Number	Completion Time
47	4.608
48	4.658
49	4.708
50	4.758
51	4.808
52	4.858
53	4.908
54	4.958
55	5.008
56	5.147
57	5.197
58	5.247
59	5.297
60	5.347
61	5.397
62	5.447
63	5.497
64	5.547
65	5.597
66	5.647
67	6.315
68	6.365
69	6.415
70	6.465
71	6.515
72	6.565
73	6.615
74	6.665
75	6.715
76	6.765
77	6.815

Vehicle Number	Completion Time
78	6.865
79	6.915
80	6.965
81	7.223
82	7.273
83	7.323
84	7.373
85	7.423
86	7.473
87	7.523
88	7.573
89	7.623
90	7.673
91	7.723
92	7.773
93	7.823
94	7.873
95	7.923
96	8.839
97	8.889
98	8.939
99	8.989
100	9.039
101	9.089
102	9.139
103	9.189
104	9.239
105	9.289
106	9.339
107	9.389
108	9.439

Vehicle Number	Completion Time
109	9.489
110	9.539
111	10.370
112	10.420
113	10.470
114	10.520
115	10.570
116	10.620
117	10.670
118	10.720
119	10.770
120	10.820
121	10.870
122	11.554
123	11.604
124	11.654
125	11.704
126	11.754
127	11.804
128	11.854
129	11.904
130	11.954
131	12.004
132	12.054
133	12.104
134	12.154
135	12.204
136	12.835
137	12.885
138	12.935
139	12.985

Vehicle Number	Completion Time
140	13.035
141	13.085
142	13.135
143	13.185
144	13.235
145	13.285
146	13.335
147	13.385
148	14.079
149	14.129
150	14.179
151	14.229
152	14.279
153	14.329
154	14.379
155	14.429
156	14.479
157	14.529
158	14.579
159	14.629
160	14.679
161	14.729
162	14.860
163	14.910
164	14.960
165	15.010
166	15.060
167	15.110
168	15.160
169	15.210
170	15.260

Vehicle Number	Completion Time
171	15.310
172	15.360
173	15.410
174	15.460
175	15.510
176	15.560
177	15.610
178	15.660
179	15.710
180	15.881
181	15.931
182	15.981
183	16.031
184	16.081
185	16.131
186	16.181
187	16.231
188	16.281
189	16.331
190	16.381
191	16.431
192	16.481
193	16.531
194	16.581
195	16.631
196	16.681
197	16.866
198	16.916
199	16.966
200	17.016
201	17.066

Vehicle Number	Completion Time
202	17.116
203	17.166
204	17.216
205	17.266
206	17.316
207	17.366
208	17.416
209	17.466
210	17.516
211	17.566
212	17.616
213	17.767
214	17.817
215	17.867
216	17.917
217	17.967
218	18.017
219	18.067
220	18.117
221	18.167
222	18.217
223	18.267
224	18.317
225	18.367
226	18.417
227	18.467
228	18.517
229	18.567
230	18.617
231	18.667
232	18.717

Vehicle Number	Completion Time
233	18.767
234	18.817
235	18.867
236	18.972
237	19.022
238	19.072
239	19.122
240	19.172
241	19.222
242	20.037
243	20.087
244	20.137
245	20.187
246	20.237
247	20.457
248	20.507
249	20.557
250	20.607
251	20.657
252	21.598
253	21.648
254	21.698
255	21.748
256	21.798
257	21.848
258	21.898
259	21.948
260	22.949
261	22.999
262	23.049
263	23.099

Vehicle Number	Completion Time
264	23.149
265	23.199
266	23.249
267	23.299
268	23.349
269	24.055
270	24.105
271	24.155
272	24.205
273	24.255
274	24.305
275	24.355
276	24.405
277	24.455
278	24.505
279	24.555
280	24.605
281	24.655
282	24.705
283	24.755
284	24.805
285	25.378
286	25.428
287	25.478
288	25.528
289	25.578
290	25.628
291	25.678
292	25.728
293	25.778
294	25.828

Vehicle Number	Completion Time
295	25.878
296	26.486
297	26.536
298	26.586
299	26.636
300	26.686
301	26.736
302	26.786
303	26.836
304	26.886
305	26.936
306	28.121
307	28.171
308	28.221
309	28.271
310	28.321
311	28.371
312	28.421
313	28.471
314	29.476
315	29.526
316	29.576
317	29.626
318	29.676
319	29.726
320	29.776
321	29.826
322	29.876
323	29.926
324	30.082
325	30.132

Vehicle Number	Completion Time
326	30.182
327	30.232
328	30.282
329	30.332
330	30.382
331	30.432
332	30.482
333	30.532
334	30.582
335	30.632
336	30.682
337	30.732
338	30.782
339	30.832
340	30.950
341	31.000
342	31.050
343	31.100
344	31.150
345	31.200
346	31.250
347	31.300
348	31.350
349	31.400
350	31.450
351	31.500
352	31.550
353	31.600
354	31.650
355	31.700
356	31.750

Vehicle Number	Completion Time
357	31.800
358	32.000
359	32.050
360	32.100
361	32.150
362	32.200
363	32.250
364	32.300
365	32.350
366	32.400
367	32.450
368	32.500
369	32.550
370	32.600
371	32.650
372	32.700
373	32.750
374	32.800
375	32.850
376	32.900
377	32.950
378	33.000
379	33.050
380	33.294
381	33.344
382	33.394
383	33.444
384	33.494
385	33.544
386	33.594
387	33.644

Vehicle Number	Completion Time
388	33.694
389	33.744
390	34.749
391	34.799
392	34.849
393	34.899
394	34.949
395	34.999
396	35.049
397	35.099
398	35.149
399	36.351
400	36.401
401	36.451
402	36.501
403	36.551
404	36.601
405	36.651
406	36.701
407	36.751
408	36.801
409	36.851
410	36.901
411	36.951
412	37.001
413	37.051
414	37.101
415	37.151
416	37.201
417	37.431
418	37.481

Vehicle Number	Completion Time
419	37.531
420	37.581
421	37.631
422	37.681
423	37.731
424	37.781
425	37.831
426	37.881
427	37.931
428	39.036
429	39.086
430	39.136
431	39.186
432	39.236
433	39.286
434	39.336
435	39.439
436	39.489
437	39.539
438	39.589
439	39.639
440	39.689
441	39.739
442	39.789
443	39.916
444	39.966
445	40.016
446	40.066
447	40.116
448	40.166
449	40.216

Vehicle Number	Completion Time
450	40.266
451	40.452
452	40.502
453	40.552
454	40.602
455	40.652
456	40.702
457	40.752
458	40.802
459	40.852
460	41.265
461	41.315
462	41.365
463	41.415
464	41.465
465	41.515
466	41.565
467	41.615
468	41.665
469	41.715
470	41.765
471	41.934
472	41.984
473	42.034
474	42.084
475	42.134
476	42.184
477	42.234
478	42.284
479	42.334
480	42.384

Vehicle Number	Completion Time
481	42.434
482	42.484
483	42.534
484	42.584
485	42.634
486	42.684
487	42.734
488	42.857
489	42.907
490	42.957
491	43.007
492	43.057
493	43.107
494	43.157
495	43.207
496	43.257
497	43.307
498	43.357
499	43.407
500	43.457
501	43.507
502	43.557
503	43.607
504	43.657
505	43.707
506	43.913
507	43.963
508	44.013
509	44.063
510	44.113
511	44.163

Vehicle Number	Completion Time
512	44.213
513	44.263
514	44.313
515	44.363
516	44.413
517	44.463
518	44.513
519	44.563
520	44.613
521	44.663
522	44.713
523	44.763
524	44.813
525	44.863
526	44.913
527	44.963
528	45.013
529	45.291
530	45.341
531	45.391
532	45.441
533	45.491
534	45.541
535	45.591
536	45.641
537	45.691
538	46.577
539	46.627
540	46.677
541	46.727
542	46.777

Vehicle Number	Completion Time
543	46.827
544	46.877
545	46.927
546	46.977
547	47.863
548	47.913
549	47.963
550	48.013
551	48.063
552	48.113
553	48.163
554	48.213
555	48.263
556	49.197
557	49.247
558	49.297
559	49.347
560	49.397
561	49.447
562	49.497
563	49.547
564	49.597
565	50.668
566	50.718
567	50.768
568	50.818
569	50.868
570	50.918
571	50.968
572	51.018
573	51.068

Vehicle Number	Completion Time
574	51.118
575	51.168
576	51.218
577	51.268
578	51.318
579	51.832
580	51.882
581	51.932
582	51.982
583	52.032
584	52.082
585	52.132
586	52.182
587	52.232
588	52.282
589	52.332
590	52.382
591	52.432
592	52.482
593	52.532
594	52.582
595	52.632
596	52.682
597	52.732
598	52.782
599	52.832
600	52.882

### Simulation Input Data:

#### JMIC Assignment Data

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1	1	0	1	1
2	1	1	1	1
3	1	2	1	1
4	1	3	1	1
5	1	0	2	1
6	1	1	2	1
7	1	2	2	1
8	1	3	2	1
9	1	0	1	1
10	1	1	1	1
11	1	2	1	1
12	1	3	1	1
13	1	0	1	1
14	1	1	1	1
15	1	2	1	1
16	1	3	1	1
17	1	0	1	1
18	1	1	1	1
19	1	2	1	1
20	1	3	1	1
21	1	0	1	1
22	1	1	1	1
23	1	2	1	1
24	1	3	1	1
25	1	0	1	1
26	1	1	1	1

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
27	1	2	1	1
28	1	3	1	1
29	1	0	1	1
30	1	1	1	1
31	1	2	1	1
32	1	3	1	1
33	1	0	1	13
34	1	1	1	13
35	1	2	1	13
36	1	3	1	13
37	2	0	1	13
38	2	1	1	13
39	2	2	1	13
40	2	3	1	13
41	2	0	2	13
42	2	1	2	3
43	2	2	2	3
44	2	3	2	3
45	2	0	3	3
46	2	1	3	3
47	2	2	3	3
48	2	3	3	3
49	2	2	1	3
50	2	3	1	2
51	2	0	2	13
52	2	1	1	4
53	2	0	1	4
54	3	0	1	4
55	3	1	1	4
56	3	2	1	4

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
57	3	3	1	4
58	3	0	2	4
59	3	0	1	4
60	3	1	1	4
61	3	2	1	4
62	3	3	1	4
63	3	1	2	4
64	4	0	1	4
65	4	1	1	4
66	4	2	1	4
67	4	3	1	4
68	4	0	2	4
69	4	0	1	4
70	4	1	1	4
71	4	2	1	4
72	4	3	1	4
73	4	1	2	4
74	5	0	1	4
75	5	1	1	4
76	5	2	1	4
77	5	3	1	4
78	5	0	2	4
79	5	0	1	4
80	5	1	1	4
81	5	2	1	4
82	5	3	1	4
83	5	1	2	4
84	6	0	1	4
85	6	1	1	4
86	6	2	1	4

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
87	6	3	1	4
88	6	0	2	4
89	6	1	2	4
90	6	2	2	4
91	6	0	1	4
92	6	1	1	3
93	6	2	1	3
94	6	3	1	3
95	6	0	2	3
96	6	1	2	3
97	6	2	2	3
98	7	0	1	3
99	7	1	1	3
100	7	2	1	13
101	7	3	1	13
102	7	0	2	3
103	7	1	2	3
104	7	2	2	3
105	7	3	2	3
106	7	0	3	3
107	7	1	3	3
108	7	2	3	3
109	7	3	3	3
110	7	0	4	2
111	7	3	1	2
112	7	2	2	2
113	7	0	1	2
114	7	1	1	6
115	7	2	1	6
116	8	0	1	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
117	8	1	1	8
118	8	2	1	3
119	8	3	1	3
120	8	0	2	3
121	8	1	2	3
122	8	2	2	3
123	8	3	2	3
124	8	0	3	10
125	8	1	3	10
126	8	2	3	2
127	8	3	1	2
128	8	0	1	2
129	8	1	1	11
130	8	2	1	8
131	9	0	1	1
132	9	1	1	1
133	9	2	1	1
134	9	3	1	1
135	9	0	2	1
136	9	1	2	1
137	9	2	2	1
138	9	3	2	1
139	9	0	3	8
140	9	1	3	8
141	9	2	3	8
142	9	3	3	8
143	9	0	4	8
144	9	1	4	8
145	9	2	1	8
146	9	3	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
147	9	0	2	13
148	9	1	2	13
149	9	0	1	2
150	9	1	1	10
151	9	0	1	10
152	9	1	1	2
153	9	0	1	10
154	9	1	1	10
155	9	0	1	2
156	9	1	1	10
157	9	0	1	10
158	9	1	1	2
159	9	0	1	2
160	9	1	1	2
161	9	0	1	3
162	9	1	1	3
163	10	0	1	3
164	10	1	1	3
165	10	2	1	3
166	10	3	1	3
167	10	0	2	2
168	10	1	2	2
169	10	2	2	2
170	10	3	2	5
171	10	0	3	5
172	10	1	3	2
173	10	2	3	2
174	10	3	3	8
175	10	0	4	8
176	10	1	4	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
177	10	2	4	8
178	10	1	1	8
179	10	2	1	8
180	10	3	1	8
181	10	0	2	8
182	10	1	2	11
183	10	2	2	11
184	10	0	1	11
185	10	1	1	11
186	10	2	1	2
187	10	0	1	10
188	10	1	1	10
189	10	0	1	2
190	10	0	1	10
191	10	0	1	10
192	10	0	1	2
193	11	0	1	10
194	11	1	1	10
195	11	2	1	2
196	11	3	1	10
197	11	0	2	10
198	11	1	2	2
199	11	2	2	2
200	11	3	2	2
201	11	0	3	2
202	11	1	3	2
203	11	2	3	2
204	11	3	3	2
205	11	0	4	2
206	11	1	4	10

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
207	11	2	4	10
208	11	0	1	8
209	11	1	2	8
210	11	2	2	8
211	11	0	1	8
212	11	1	1	8
213	11	2	1	8
214	11	3	1	8
215	11	0	2	8
216	11	1	2	9
217	11	0	1	9
218	11	1	1	9
219	11	2	1	9
220	11	1	1	9
221	11	0	1	9
222	11	1	1	9
223	11	0	1	9
224	11	1	1	9
225	11	0	1	9
226	11	1	1	9
227	11	0	1	9
228	11	1	1	11
229	11	0	1	11
230	11	0	1	11
231	11	0	1	11
232	12	0	1	9
233	12	1	1	9
234	12	2	1	9
235	12	3	1	9
236	12	0	2	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
237	12	1	2	9
238	12	2	2	9
239	12	3	2	9
240	12	0	3	9
241	12	1	3	9
242	12	2	3	9
243	12	0	1	9
244	12	1	1	11
245	12	2	1	11
246	12	3	2	11
247	12	0	2	11
248	12	1	2	7
249	12	2	2	7
250	12	3	3	7
251	12	0	3	7
252	12	0	1	7
253	12	1	1	7
254	12	2	1	7
255	12	3	1	7
256	12	0	2	12
257	12	1	2	12
258	12	2	2	12
259	12	3	2	12
260	12	0	3	7
261	12	1	3	7
262	12	0	1	7
263	12	1	1	7
264	12	2	1	7
265	12	3	1	7
266	12	0	2	7

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
267	12	1	2	7
268	12	2	2	12
269	12	3	2	12
270	12	0	3	12
271	12	1	3	12
272	12	2	2	8
273	12	3	2	8
274	12	0	1	8
275	12	1	1	8
276	12	2	1	8
277	12	3	1	8
278	12	0	2	8
279	12	1	2	8
280	12	0	1	8
281	12	1	1	8
282	12	2	1	8
283	12	3	1	8
284	12	0	2	8
285	12	1	2	8
286	12	0	1	8
287	12	1	1	8
288	12	2	1	11
289	12	3	1	11
290	12	0	2	11
291	12	1	2	11
292	12	0	1	2
293	12	1	1	8
294	12	2	1	8
295	12	3	1	8
296	12	0	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
297	12	0	1	8
298	12	0	1	8
299	12	0	1	8
300	12	0	1	8
301	13	0	1	11
302	13	1	1	11
303	13	2	1	11
304	13	3	1	11
305	13	0	2	8
306	13	1	2	8
307	13	2	2	8
308	13	3	2	8
309	13	0	3	8
310	13	1	3	8
311	13	2	3	8
312	13	3	3	8
313	13	0	4	11
314	13	1	4	11
315	13	0	2	11
316	13	1	2	11
317	13	2	2	8
318	13	3	3	8
319	13	0	2	8
320	13	1	2	8
321	13	2	2	8
322	13	3	1	8
323	13	1	2	8
324	13	0	2	8
325	13	3	2	10
326	13	0	1	10

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
327	13	1	1	8
328	13	2	1	8
329	13	3	1	8
330	13	0	2	8
331	13	0	1	8
332	13	1	1	8
333	13	2	1	8
334	13	3	1	8
335	13	0	2	11
336	13	0	1	11
337	13	1	1	11
338	13	2	1	11
339	13	3	1	2
340	13	0	2	10
341	13	0	1	10
342	13	1	1	2
343	13	0	1	10
344	13	1	1	10
345	13	0	1	2
346	13	1	1	2
347	13	0	1	6
348	14	0	1	6
349	14	1	1	8
350	14	2	1	8
351	14	3	1	8
352	14	0	2	8
353	14	1	2	8
354	14	2	2	8
355	14	3	2	8
356	14	0	3	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
357	14	1	3	2
358	14	2	3	13
359	14	3	3	2
360	14	0	2	8
361	14	1	2	8
362	14	2	2	8
363	14	3	2	8
364	14	0	1	8
365	14	1	1	8
366	14	2	1	8
367	14	3	1	8
368	14	0	2	11
369	14	1	2	11
370	14	2	2	11
371	14	3	2	11
372	14	0	1	7
373	14	1	1	7
374	14	2	1	7
375	14	3	1	7
376	14	0	2	7
377	14	1	2	7
378	14	2	2	7
379	14	3	2	7
380	14	2	1	12
381	14	3	1	12
382	14	0	2	12
383	14	1	2	12
384	14	1	1	7
385	14	2	1	7
386	14	3	1	7

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
387	14	0	2	7
388	14	0	1	7
389	14	1	1	7
390	14	2	1	7
391	14	3	1	7
392	14	0	2	12
393	14	0	1	12
394	14	1	1	12
395	14	2	1	12
396	14	3	1	9
397	14	0	2	9
398	14	2	1	9
399	14	3	1	9
400	14	1	1	9
401	14	2	1	9
402	14	0	1	9
403	14	1	1	9
404	14	2	1	9
405	14	1	1	9
406	14	0	1	9
407	14	0	1	9
408	15	0	1	11
409	15	1	1	11
410	15	2	1	11
411	15	3	1	11
412	15	0	2	9
413	15	1	2	9
414	15	2	2	9
415	15	3	2	9
416	15	0	3	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
417	15	1	3	9
418	15	2	3	9
419	15	3	3	9
420	15	0	4	9
421	15	1	4	9
422	15	2	1	9
423	15	0	1	9
424	15	1	1	11
425	15	2	1	11
426	15	0	1	11
427	15	1	1	11
428	15	2	1	2
429	15	1	1	2
430	15	0	1	2
431	15	1	1	2
432	15	0	1	2
433	15	0	1	2
434	15	0	1	2
435	15	0	1	2
436	15	0	1	2
437	15	0	1	2
438	15	0	1	2
439	16	0	1	2
440	16	1	1	2
441	16	2	1	2
442	16	3	1	2
443	16	0	2	2
444	16	1	2	2
445	16	2	2	2
446	16	3	2	2

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
447	16	0	3	13
448	16	1	3	13
449	16	2	3	13
450	16	3	3	13
451	16	0	4	13
452	16	1	4	13
453	16	2	4	13
454	16	3	4	13
455	16	0	5	13
456	16	1	5	13
457	17	0	1	13
458	17	1	1	13
459	17	2	1	13
460	17	3	1	13
461	17	0	2	13
462	17	1	2	13
463	17	2	2	13
464	17	3	2	13
465	17	0	3	14
466	17	1	3	14
467	17	2	3	14
468	17	3	3	14
469	17	0	4	14
470	17	1	4	14
471	17	2	4	14
472	17	3	4	14
473	17	0	5	14
474	18	0	1	14
475	18	1	1	14
476	18	2	1	14

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
477	18	3	1	14
478	18	0	2	14
479	18	1	2	14
480	18	2	2	14
481	18	3	2	14
482	18	0	3	14
483	18	1	3	14
484	18	2	3	14
485	18	3	3	14
486	18	0	4	14
487	18	1	4	14
488	18	2	4	15
489	18	3	4	15
490	19	0	1	15
491	19	1	1	15
492	19	2	1	15
493	19	3	1	16
494	19	0	2	16
495	19	1	2	17
496	19	2	2	10
497	19	3	2	10
498	19	0	3	10
499	19	1	3	10
500	19	2	3	10
501	19	3	3	10
502	19	0	4	10
503	19	1	4	10
504	19	2	4	10
505	19	3	4	10
506	19	0	5	10

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
507	19	1	5	10
508	19	2	5	10
509	19	3	5	10
510	19	0	6	10
511	19	1	6	10
512	19	2	6	10
513	19	3	2	10
514	19	0	2	10
515	19	0	3	10
516	19	1	3	10
517	19	2	3	10
518	19	3	3	10
519	19	0	4	10
520	19	1	4	10
521	19	2	4	10
522	19	3	4	10
523	19	0	5	10
524	19	0	2	10
525	19	1	2	10
526	19	0	1	10
527	19	1	1	10
528	19	2	1	10
529	19	3	1	10
530	20	0	1	10
531	20	1	1	10
532	20	2	1	10
533	20	3	1	10
534	20	0	2	1
535	20	1	2	1
536	20	0	1	1

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
537	20	1	1	1
538	20	2	1	1
539	20	3	1	1
540	20	0	2	1
541	20	1	2	1
542	20	0	1	1
543	20	1	1	1
544	20	2	1	1
545	20	3	1	1
546	20	0	1	1
547	20	1	1	1
548	20	2	1	1
549	20	3	1	1
550	20	0	1	1
551	20	1	1	1
552	20	2	1	1
553	20	3	1	1
554	20	0	1	1
555	20	1	1	1
556	20	2	1	1
557	20	3	1	1
558	20	0	1	1
559	20	1	1	1
560	20	2	1	1
561	20	3	1	1
562	20	0	1	1
563	20	1	1	1
564	20	2	1	1
565	20	3	1	1
566	21	0	1	1

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
567	21	1	1	1
568	21	2	1	1
569	21	3	1	1
570	21	0	2	1
571	21	0	1	1
572	21	1	1	1
573	21	2	1	1
574	21	3	1	1
575	21	0	2	1
576	21	1	1	1
577	21	3	1	1
578	21	0	1	1
579	21	1	1	1
580	21	2	1	1
581	21	3	1	1
582	21	0	1	1
583	21	1	1	1
584	21	2	1	1
585	21	3	1	1
586	21	0	1	1
587	21	1	1	1
588	21	2	1	1
589	21	3	1	1
590	21	0	1	1
591	21	1	1	1
592	21	2	1	1
593	21	3	1	1
594	21	0	1	1
595	21	1	1	1
596	21	2	1	1

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
597	21	3	1	1
598	21	0	1	4
599	21	1	1	4
600	22	0	1	4
601	22	1	1	4
602	22	2	1	4
603	22	3	1	4
604	22	0	2	4
605	22	0	1	4
606	22	1	1	4
607	22	2	1	4
608	22	3	1	4
609	22	0	2	4
610	23	0	1	4
611	23	1	1	4
612	23	2	1	8
613	23	3	1	8
614	23	0	2	8
615	23	1	2	8
616	23	2	2	8
617	23	3	2	8
618	23	0	1	8
619	23	1	1	8
620	23	2	1	8
621	23	3	1	8
622	23	0	2	8
623	23	1	2	8
624	23	2	2	8
625	23	3	2	8
626	23	2	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
627	23	3	1	8
628	23	0	2	8
629	23	1	2	8
630	23	2	2	8
631	23	0	1	8
632	23	1	1	8
633	23	2	1	8
634	23	3	1	8
635	23	0	2	8
636	23	1	2	8
637	23	2	2	8
638	23	0	1	8
639	23	1	1	8
640	23	2	1	8
641	23	3	1	8
642	23	0	2	8
643	23	1	2	8
644	23	2	2	8
645	23	0	1	8
646	23	1	1	8
647	23	2	1	8
648	23	3	1	8
649	23	0	2	8
650	23	1	2	8
651	23	2	2	8
652	23	0	1	8
653	23	1	1	8
654	23	2	1	8
655	23	3	1	8
656	23	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
657	23	1	2	8
658	23	2	2	8
659	23	0	1	8
660	23	1	1	8
661	23	2	1	8
662	23	3	1	8
663	23	0	2	8
664	23	1	2	8
665	23	2	2	8
666	23	0	1	8
667	23	1	1	8
668	24	0	1	8
669	24	1	1	8
670	24	2	1	8
671	24	3	1	8
672	24	0	2	8
673	24	1	2	8
674	24	2	2	8
675	24	3	2	8
676	24	0	3	8
677	24	0	1	8
678	24	1	1	8
679	24	2	1	8
680	24	3	1	8
681	24	0	2	8
682	24	1	2	8
683	24	2	2	8
684	24	3	2	8
685	24	0	3	8
686	24	0	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
687	24	1	1	8
688	24	2	1	8
689	24	3	1	8
690	24	0	2	8
691	24	1	2	8
692	24	2	2	8
693	24	3	2	8
694	24	0	3	8
695	24	0	1	8
696	24	1	1	8
697	24	2	1	8
698	24	3	1	8
699	24	0	2	8
700	24	1	2	8
701	24	2	2	8
702	24	3	2	8
703	24	0	3	8
704	24	0	1	8
705	24	1	1	8
706	24	2	1	8
707	24	3	1	8
708	24	0	2	8
709	24	1	2	8
710	24	2	2	8
711	24	3	2	8
712	24	0	3	8
713	24	0	1	8
714	24	1	1	8
715	24	2	1	8
716	24	3	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
717	24	0	2	8
718	24	1	2	8
719	24	2	2	8
720	24	3	2	8
721	24	0	3	8
722	24	0	1	8
723	24	1	1	8
724	24	2	1	8
725	24	3	1	8
726	24	0	2	8
727	24	1	2	8
728	24	2	2	8
729	24	3	2	8
730	24	0	3	8
731	24	0	1	8
732	24	1	1	8
733	24	2	1	8
734	24	3	1	8
735	24	0	2	8
736	24	1	2	8
737	24	2	2	8
738	24	3	2	8
739	24	0	3	8
740	25	0	1	11
741	25	1	1	11
742	25	2	1	11
743	25	3	1	11
744	25	0	2	11
745	25	1	2	11
746	25	2	2	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
747	25	3	2	11
748	25	0	3	11
749	25	1	3	11
750	25	2	3	11
751	25	3	3	11
752	25	0	4	11
753	25	1	4	11
754	25	2	4	11
755	25	3	4	11
756	25	2	1	11
757	25	3	1	11
758	25	0	2	11
759	25	1	2	11
760	25	2	2	11
761	25	3	2	11
762	25	0	3	11
763	25	1	3	11
764	25	2	3	11
765	25	3	3	11
766	25	0	4	11
767	25	1	4	11
768	25	0	1	11
769	25	1	1	11
770	25	2	1	11
771	25	3	1	11
772	25	0	2	11
773	25	1	2	11
774	25	2	2	11
775	25	3	2	11
776	25	0	3	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
777	25	1	3	11
778	25	2	3	11
779	25	3	3	11
780	25	0	4	11
781	25	1	4	11
782	25	0	1	11
783	25	1	1	11
784	25	2	1	11
785	25	3	1	11
786	25	0	2	11
787	25	1	2	11
788	25	2	2	11
789	25	3	2	11
790	25	0	3	11
791	25	1	3	11
792	25	2	3	11
793	25	3	3	11
794	25	0	4	11
795	25	1	4	11
796	25	0	1	18
797	25	1	1	18
798	26	0	1	7
799	26	1	1	7
800	26	2	1	7
801	26	3	1	7
802	26	0	2	7
803	26	1	2	7
804	26	2	2	7
805	26	3	2	7
806	26	0	3	12

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
807	26	1	3	12
808	26	2	3	12
809	26	0	1	12
810	26	1	1	7
811	26	2	1	7
812	26	3	1	7
813	26	0	2	7
814	26	1	2	7
815	26	2	2	7
816	26	3	2	7
817	26	0	3	7
818	26	1	3	12
819	26	2	3	12
820	26	0	1	12
821	26	1	1	12
822	26	2	1	7
823	26	3	1	7
824	26	0	2	7
825	26	1	2	7
826	26	2	2	7
827	26	3	2	7
828	26	0	3	7
829	26	1	3	7
830	26	2	3	12
831	26	0	1	12
832	26	1	1	12
833	26	2	1	12
834	26	3	1	7
835	26	0	2	7
836	26	1	2	7

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
837	26	2	2	7
838	26	3	2	7
839	26	0	3	7
840	26	1	3	7
841	26	2	3	7
842	26	2	1	12
843	26	3	1	12
844	26	0	2	12
845	26	1	2	12
846	26	0	1	7
847	26	1	1	7
848	26	2	1	7
849	26	3	1	7
850	26	0	2	7
851	26	1	2	7
852	26	0	1	7
853	26	1	1	7
854	26	2	1	12
855	26	3	1	12
856	26	0	2	12
857	26	1	2	12
858	26	0	1	7
859	26	1	1	7
860	26	2	1	7
861	26	3	1	7
862	26	0	2	7
863	26	1	2	7
864	26	0	1	7
865	26	1	1	7
866	27	0	1	12

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
867	27	1	1	12
868	27	2	1	12
869	27	3	1	12
870	27	0	2	20
871	27	1	2	21
872	27	2	2	21
873	27	3	2	21
874	27	0	3	8
875	27	1	3	8
876	27	2	1	8
877	27	3	1	8
878	27	0	1	8
879	27	1	1	8
880	27	2	1	8
881	27	3	1	8
882	27	0	1	8
883	27	1	1	8
884	27	2	1	8
885	27	3	1	8
886	27	0	1	8
887	27	1	1	8
888	27	2	1	8
889	27	3	1	8
890	27	0	1	9
891	27	1	1	9
892	27	2	1	9
893	27	0	1	9
894	27	1	1	9
895	27	2	1	9
896	27	0	1	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
897	27	1	1	9
898	27	2	1	9
899	27	1	1	9
900	27	0	1	9
901	27	1	1	9
902	28	0	1	11
903	28	0	1	11
904	28	0	1	11
905	28	1	1	11
906	28	2	1	9
907	28	3	1	9
908	28	0	2	9
909	28	1	2	9
910	28	2	2	9
911	28	3	2	9
912	28	0	1	9
913	28	1	1	9
914	28	2	1	9
915	28	3	1	9
916	28	0	2	9
917	28	1	2	9
918	28	2	2	11
919	28	3	2	11
920	28	0	1	11
921	28	1	1	11
922	28	2	1	9
923	28	3	1	9
924	28	0	2	9
925	28	1	2	9
926	28	2	2	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
927	28	3	2	9
928	28	0	1	9
929	28	1	1	9
930	28	2	1	9
931	28	3	1	9
932	28	0	2	9
933	28	1	2	9
934	28	2	2	11
935	28	3	2	11
936	28	0	1	11
937	28	1	1	11
938	28	2	1	9
939	28	3	1	9
940	28	0	1	9
941	28	1	1	9
942	28	2	1	9
943	28	3	1	9
944	28	0	1	9
945	28	1	1	9
946	28	2	1	9
947	28	3	1	9
948	28	0	1	9
949	28	1	1	9
950	28	2	1	11
951	28	3	1	11
952	28	0	1	11
953	28	1	1	11
954	28	2	1	9
955	28	3	1	9
956	28	0	1	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
957	28	1	1	9
958	28	2	1	9
959	28	3	1	9
960	28	0	1	9
961	28	1	1	9
962	28	2	1	9
963	28	3	1	9
964	28	0	1	9
965	28	1	1	9
966	29	2	1	11
967	29	3	1	11
968	29	0	1	11
969	29	1	1	11
970	29	2	1	9
971	29	3	1	9
972	29	0	2	9
973	29	1	2	9
974	29	2	2	9
975	29	3	2	9
976	29	0	3	9
977	29	1	3	9
978	29	0	1	9
979	29	0	2	9
980	29	1	2	9
981	29	2	2	9
982	29	0	1	11
983	29	1	1	11
984	29	2	1	11
985	29	3	1	11
986	29	0	2	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
987	29	1	2	9
988	29	2	2	9
989	29	0	1	9
990	29	1	1	9
991	29	2	1	9
992	29	3	1	9
993	29	0	2	9
994	29	1	2	9
995	29	2	2	9
996	29	3	1	9
997	29	0	2	9
998	29	0	1	11
999	29	1	1	11
1000	29	2	1	11
1001	29	3	1	11
1002	29	0	2	9
1003	29	2	1	9
1004	29	0	1	9
1005	29	1	1	9
1006	29	2	1	9
1007	29	0	1	9
1008	29	1	1	9
1009	29	2	1	9
1010	29	0	1	9
1011	29	1	1	9
1012	29	2	1	9
1013	29	0	1	9
1014	29	1	1	11
1015	29	2	1	11
1016	29	0	1	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1017	29	1	1	11
1018	29	2	1	13
1019	29	1	1	13
1020	29	0	1	14
1021	30	0	1	14
1022	30	0	1	14
1023	30	0	1	14
1024	30	1	1	14
1025	30	2	1	14
1026	30	3	1	14
1027	30	0	2	14
1028	30	1	2	14
1029	30	2	2	14
1030	30	3	2	14
1031	30	0	3	14
1032	30	1	3	14
1033	30	2	3	14
1034	30	3	3	14
1035	30	0	4	14
1036	30	1	4	14
1037	31	2	4	17
1038	31	3	4	2
1039	31	0	1	2
1040	31	1	1	2
1041	31	2	1	2
1042	31	3	1	2
1043	31	0	2	2
1044	31	1	2	2
1045	31	2	2	2
1046	31	3	2	2

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1047	31	0	3	2
1048	31	1	3	2
1049	31	2	3	2
1050	31	3	3	2
1051	31	0	4	2
1052	31	1	4	2
1053	31	2	4	2
1054	31	3	4	2
1055	32	0	5	2
1056	32	1	5	2
1057	32	0	1	2
1058	32	1	1	2
1059	32	2	1	2
1060	32	3	1	2
1061	32	0	2	2
1062	32	1	2	2
1063	32	2	2	2
1064	32	3	2	10
1065	32	0	3	10
1066	32	1	3	10
1067	32	2	3	10
1068	32	3	3	10
1069	32	0	4	10
1070	32	1	4	10
1071	32	2	4	10
1072	32	3	4	10
1073	32	0	5	10
1074	32	1	5	10
1075	32	2	5	10
1076	32	3	5	10

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1077	32	0	6	10
1078	32	1	6	10
1079	32	2	3	10
1080	32	3	3	10
1081	32	1	3	10
1082	32	0	4	10
1083	32	0	3	10
1084	32	3	1	10
1085	32	0	2	10
1086	32	1	2	10
1087	32	2	2	10
1088	32	3	2	10
1089	32	2	1	10
1090	33	1	1	10
1091	33	0	1	10
1092	33	0	1	10
1093	33	1	1	10
1094	33	2	1	8
1095	33	3	1	8
1096	33	0	2	8
1097	33	1	2	8
1098	33	2	2	8
1099	33	3	2	8
1100	33	0	3	8
1101	33	1	3	8
1102	33	0	1	8
1103	33	1	1	8
1104	33	2	1	8
1105	33	3	1	8
1106	33	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1107	33	1	2	8
1108	33	2	2	8
1109	33	3	2	8
1110	33	0	3	8
1111	33	1	3	8
1112	33	2	2	8
1113	33	3	2	8
1114	33	0	2	8
1115	33	1	2	8
1116	33	0	1	8
1117	33	1	1	8
1118	33	2	1	8
1119	33	3	1	8
1120	33	0	2	8
1121	33	1	2	8
1122	33	2	2	8
1123	33	3	2	8
1124	33	0	1	8
1125	33	1	1	8
1126	33	2	1	8
1127	33	3	1	8
1128	33	0	2	8
1129	33	1	2	8
1130	33	2	2	8
1131	33	3	2	8
1132	33	0	1	8
1133	33	1	1	8
1134	33	2	1	8
1135	33	3	1	8
1136	33	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1137	33	1	2	8
1138	33	2	2	8
1139	33	3	2	8
1140	33	0	1	8
1141	33	1	1	8
1142	33	2	1	8
1143	33	3	1	8
1144	33	0	2	8
1145	33	1	2	8
1146	33	2	2	8
1147	33	3	2	8
1148	33	0	1	8
1149	33	1	1	8
1150	33	2	1	8
1151	33	3	1	8
1152	33	0	2	8
1153	33	1	2	8
1154	33	2	2	8
1155	33	3	2	8
1156	33	0	1	8
1157	33	1	1	8
1158	34	2	1	8
1159	34	3	1	8
1160	34	0	1	8
1161	34	1	1	8
1162	34	2	1	8
1163	34	3	1	8
1164	34	0	2	8
1165	34	1	2	8
1166	34	2	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1167	34	3	2	8
1168	34	0	3	8
1169	34	0	1	8
1170	34	1	1	8
1171	34	2	1	8
1172	34	3	1	8
1173	34	0	2	8
1174	34	1	2	8
1175	34	2	2	8
1176	34	3	2	8
1177	34	0	3	8
1178	34	0	1	8
1179	34	1	1	8
1180	34	2	1	8
1181	34	3	1	8
1182	34	0	2	8
1183	34	1	2	8
1184	34	2	2	8
1185	34	3	2	8
1186	34	0	3	8
1187	34	0	1	8
1188	34	1	1	8
1189	34	2	1	8
1190	34	3	1	8
1191	34	0	2	8
1192	34	1	2	8
1193	34	2	2	8
1194	34	3	2	8
1195	34	0	3	8
1196	34	0	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1197	34	1	1	8
1198	34	2	1	8
1199	34	3	1	8
1200	34	0	2	8
1201	34	1	2	8
1202	34	2	2	8
1203	34	3	2	8
1204	34	0	3	8
1205	34	0	1	8
1206	34	1	1	8
1207	34	2	1	8
1208	34	3	1	8
1209	34	0	2	8
1210	34	1	2	8
1211	34	2	2	8
1212	34	3	2	8
1213	34	0	3	8
1214	34	0	1	8
1215	34	1	1	8
1216	34	2	1	8
1217	34	3	1	8
1218	34	0	2	8
1219	34	1	2	8
1220	34	2	2	8
1221	34	3	2	8
1222	34	0	3	8
1223	34	0	1	8
1224	34	1	1	8
1225	34	2	1	8
1226	34	3	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1227	34	0	2	8
1228	34	1	2	8
1229	34	2	2	8
1230	35	3	2	8
1231	35	0	3	8
1232	35	0	1	8
1233	35	1	1	8
1234	35	2	1	8
1235	35	3	1	8
1236	35	0	2	8
1237	35	1	2	8
1238	35	2	2	8
1239	35	3	2	8
1240	35	0	3	8
1241	35	1	3	8
1242	35	2	3	8
1243	35	3	3	8
1244	35	0	4	8
1245	35	1	4	8
1246	35	2	4	11
1247	35	3	4	11
1248	35	0	5	11
1249	35	1	5	11
1250	35	0	1	11
1251	35	1	1	11
1252	35	2	1	11
1253	35	3	1	11
1254	35	0	2	11
1255	35	1	2	11
1256	35	2	2	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1257	35	3	2	11
1258	35	0	3	11
1259	35	1	3	11
1260	35	2	3	11
1261	35	3	3	11
1262	35	0	4	11
1263	35	1	4	11
1264	35	2	4	11
1265	35	3	4	11
1266	35	0	5	11
1267	35	1	5	11
1268	35	0	1	11
1269	35	1	1	11
1270	35	2	1	11
1271	35	3	1	11
1272	35	0	2	11
1273	35	1	2	11
1274	35	2	2	11
1275	35	3	2	11
1276	35	0	3	11
1277	35	1	3	11
1278	35	2	3	11
1279	35	3	3	11
1280	35	0	4	11
1281	35	1	4	11
1282	35	2	4	11
1283	35	3	4	11
1284	35	0	5	11
1285	35	1	5	11
1286	35	0	1	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1287	35	1	1	11
1288	35	2	1	11
1289	35	3	1	11
1290	35	0	2	11
1291	35	1	2	11
1292	35	2	2	11
1293	35	3	2	11
1294	35	0	3	11
1295	35	1	3	11
1296	35	2	3	11
1297	35	3	3	11
1298	35	0	4	11
1299	35	1	4	11
1300	35	2	4	11
1301	35	3	4	11
1302	35	0	5	11
1303	35	1	5	11
1304	35	0	1	11
1305	35	1	1	11
1306	35	0	1	11
1307	35	1	1	11
1308	35	0	1	11
1309	35	1	1	11
1310	36	0	1	11
1311	36	1	1	11
1312	36	0	1	11
1313	36	1	1	11
1314	36	2	1	11
1315	36	3	1	11
1316	36	0	2	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1317	36	1	2	11
1318	36	2	2	11
1319	36	3	2	11
1320	36	0	3	11
1321	36	1	3	11
1322	36	2	3	11
1323	36	3	1	11
1324	36	0	1	11
1325	36	1	1	11
1326	36	2	1	8
1327	36	3	1	8
1328	36	0	1	8
1329	36	1	1	8
1330	36	2	1	8
1331	36	3	1	8
1332	36	2	1	22
1333	37	1	1	9
1334	37	0	1	9
1335	37	0	1	9
1336	37	1	1	9
1337	37	2	1	9
1338	37	3	1	9
1339	37	0	2	9
1340	37	1	2	9
1341	37	2	2	9
1342	37	0	1	9
1343	37	1	1	9
1344	37	2	1	9
1345	37	3	1	9
1346	37	0	2	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1347	37	1	2	9
1348	37	2	2	9
1349	37	0	1	9
1350	37	1	1	9
1351	37	2	1	9
1352	37	3	1	9
1353	37	0	2	9
1354	37	1	2	9
1355	37	2	2	9
1356	37	0	1	9
1357	37	1	1	9
1358	37	2	1	9
1359	37	3	1	9
1360	37	0	2	9
1361	37	1	2	9
1362	37	2	2	9
1363	37	0	1	9
1364	37	1	1	9
1365	37	2	1	9
1366	37	3	1	9
1367	37	0	2	9
1368	37	1	2	9
1369	37	2	2	9
1370	37	0	1	9
1371	37	1	1	9
1372	37	2	1	9
1373	37	3	1	9
1374	37	0	2	9
1375	37	1	2	9
1376	37	2	2	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1377	37	0	1	9
1378	37	1	1	9
1379	37	2	1	9
1380	37	3	1	9
1381	37	0	2	9
1382	37	1	2	9
1383	37	2	2	9
1384	37	0	1	9
1385	37	1	1	9
1386	37	2	1	9
1387	37	3	1	9
1388	37	0	2	9
1389	37	1	2	9
1390	37	2	2	9
1391	37	0	1	9
1392	37	1	1	9
1393	37	2	1	9
1394	37	3	1	9
1395	37	0	2	9
1396	37	1	2	9
1397	37	2	2	9
1398	37	0	1	9
1399	37	1	1	9
1400	37	2	1	9
1401	37	3	1	9
1402	37	0	2	9
1403	37	1	2	9
1404	37	2	2	9
1405	37	0	1	9
1406	37	1	1	9

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1407	37	2	1	9
1408	37	3	1	9
1409	37	0	2	9
1410	37	1	2	9
1411	37	2	2	9
1412	37	0	1	9
1413	37	1	1	9
1414	37	2	1	9
1415	37	3	1	9
1416	37	0	2	9
1417	38	1	2	18
1418	38	2	2	18
1419	38	0	1	18
1420	38	1	1	18
1421	38	2	1	23
1422	38	3	1	23
1423	38	0	2	23
1424	38	1	2	23
1425	39	2	2	23
1426	39	3	2	23
1427	39	0	1	20
1428	39	1	1	20
1429	40	2	1	20
1430	40	3	1	20
1431	40	0	2	20
1432	40	1	2	25
1433	40	2	2	25
1434	40	3	2	26
1435	40	0	1	6
1436	40	1	1	27

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1437	40	2	1	27
1438	41	3	1	7
1439	41	0	2	7
1440	41	1	2	7
1441	41	2	2	7
1442	41	3	2	7
1443	41	0	3	7
1444	41	0	1	7
1445	41	1	1	7
1446	41	2	1	7
1447	41	3	1	7
1448	41	0	2	7
1449	41	1	2	7
1450	41	2	2	7
1451	41	3	2	7
1452	41	0	3	7
1453	41	1	3	7
1454	41	2	3	7
1455	41	2	1	7
1456	41	0	1	7
1457	41	1	1	7
1458	41	2	1	7
1459	41	0	1	7
1460	41	1	1	7
1461	41	2	1	7
1462	41	0	1	14
1463	41	1	1	14
1464	41	2	1	14
1465	41	0	1	14
1466	42	1	1	14

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1467	42	2	1	14
1468	42	0	1	14
1469	42	1	1	14
1470	42	2	1	14
1471	42	0	1	14
1472	42	1	1	14
1473	42	2	1	14
1474	42	0	1	14
1475	42	1	1	14
1476	42	0	1	2
1477	42	1	1	2
1478	42	2	1	2
1479	42	3	1	2
1480	42	0	2	2
1481	42	1	2	2
1482	42	2	2	2
1483	43	3	2	2
1484	43	0	3	2
1485	43	1	3	2
1486	43	2	3	2
1487	43	3	3	2
1488	43	0	4	2
1489	43	1	4	2
1490	43	2	4	2
1491	43	3	4	2
1492	43	0	5	2
1493	43	0	1	2
1494	43	1	1	2
1495	43	2	1	2
1496	43	3	1	2

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1497	43	0	2	2
1498	43	1	2	2
1499	43	2	2	2
1500	43	3	2	2
1501	44	0	3	2
1502	44	1	3	10
1503	44	2	3	10
1504	44	3	3	10
1505	44	0	4	10
1506	44	1	4	10
1507	44	2	4	10
1508	44	3	4	10
1509	44	0	5	10
1510	44	1	5	10
1511	44	0	1	10
1512	44	1	1	10
1513	44	2	1	10
1514	44	3	1	10
1515	44	0	2	10
1516	44	1	2	10
1517	44	2	2	10
1518	44	3	2	10
1519	44	0	3	10
1520	44	1	3	10
1521	44	2	3	10
1522	44	3	3	10
1523	44	0	4	10
1524	44	1	4	10
1525	44	2	4	10
1526	44	3	4	10

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1527	44	0	5	10
1528	44	1	5	10
1529	44	2	5	10
1530	44	3	5	10
1531	44	0	6	10
1532	44	1	6	10
1533	44	2	6	10
1534	44	2	1	10
1535	44	3	1	10
1536	44	0	2	10
1537	44	1	2	10
1538	44	2	2	10
1539	44	3	2	10
1540	44	0	3	10
1541	44	1	3	10
1542	44	2	3	10
1543	44	3	3	10
1544	45	0	4	8
1545	45	1	4	8
1546	45	2	4	8
1547	45	3	4	8
1548	45	0	5	8
1549	45	1	5	8
1550	45	2	5	8
1551	45	3	5	8
1552	45	0	6	8
1553	45	0	1	8
1554	45	1	1	8
1555	45	0	1	8
1556	45	1	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1557	45	2	1	8
1558	45	3	1	8
1559	45	0	2	8
1560	45	1	2	8
1561	45	2	2	8
1562	45	3	2	8
1563	45	0	3	8
1564	45	0	1	8
1565	45	1	1	8
1566	45	2	1	8
1567	45	3	1	8
1568	45	0	2	8
1569	45	1	2	8
1570	45	2	2	8
1571	45	3	2	8
1572	45	0	3	8
1573	45	0	1	8
1574	45	1	1	8
1575	45	2	1	8
1576	45	3	1	8
1577	45	0	2	8
1578	45	1	2	8
1579	45	2	2	8
1580	45	3	2	8
1581	45	0	3	8
1582	45	0	1	8
1583	45	1	1	8
1584	45	2	1	8
1585	45	3	1	8
1586	45	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1587	45	1	2	8
1588	45	2	2	8
1589	45	3	2	8
1590	45	0	3	8
1591	45	0	1	8
1592	45	1	1	8
1593	45	2	1	8
1594	45	3	1	8
1595	45	0	2	8
1596	45	1	2	8
1597	45	2	2	8
1598	45	3	2	8
1599	45	0	3	8
1600	45	0	1	8
1601	45	1	1	8
1602	45	2	1	8
1603	45	3	1	8
1604	45	0	2	8
1605	45	1	2	8
1606	45	2	2	8
1607	45	3	2	8
1608	45	0	3	8
1609	45	0	1	8
1610	45	1	1	8
1611	45	2	1	8
1612	45	3	1	8
1613	45	0	2	8
1614	45	1	2	8
1615	45	2	2	8
1616	46	3	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1617	46	0	3	8
1618	46	0	1	8
1619	46	1	1	8
1620	46	2	1	8
1621	46	3	1	8
1622	46	0	2	8
1623	46	1	2	8
1624	46	2	2	8
1625	46	3	2	8
1626	46	0	3	8
1627	46	0	1	8
1628	46	1	1	8
1629	46	2	1	8
1630	46	3	1	8
1631	46	0	2	8
1632	46	1	2	8
1633	46	2	2	8
1634	46	3	2	8
1635	46	0	3	8
1636	46	0	1	8
1637	46	1	1	8
1638	46	2	1	8
1639	46	3	1	8
1640	46	0	2	8
1641	46	1	2	8
1642	46	2	2	8
1643	46	3	2	8
1644	46	0	3	8
1645	46	0	1	8
1646	46	1	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1647	46	2	1	8
1648	46	3	1	8
1649	46	0	2	8
1650	46	1	2	8
1651	46	2	2	8
1652	46	3	2	8
1653	46	0	3	8
1654	46	0	1	8
1655	46	1	1	8
1656	46	2	1	8
1657	46	3	1	8
1658	46	0	2	8
1659	46	1	2	8
1660	46	2	2	8
1661	46	3	2	8
1662	46	0	3	8
1663	46	0	1	8
1664	46	1	1	8
1665	46	2	1	8
1666	46	3	1	8
1667	46	0	2	8
1668	46	1	2	8
1669	46	2	2	8
1670	46	3	2	8
1671	46	0	3	8
1672	46	0	1	8
1673	46	1	1	8
1674	46	2	1	8
1675	46	3	1	8
1676	46	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1677	46	1	2	8
1678	46	2	2	8
1679	46	3	2	8
1680	46	0	3	8
1681	46	0	1	8
1682	46	1	1	8
1683	46	2	1	8
1684	46	3	1	8
1685	46	0	2	8
1686	46	1	2	8
1687	46	2	2	8
1688	47	3	2	8
1689	47	0	3	8
1690	47	0	1	8
1691	47	1	1	8
1692	47	2	1	8
1693	47	3	1	8
1694	47	0	2	8
1695	47	1	2	8
1696	47	2	2	8
1697	47	3	2	8
1698	47	0	3	8
1699	47	0	1	8
1700	47	1	1	8
1701	47	2	1	8
1702	47	3	1	8
1703	47	0	2	8
1704	47	1	2	8
1705	47	2	2	8
1706	47	3	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1707	47	0	3	8
1708	47	0	1	8
1709	47	1	1	8
1710	47	2	1	8
1711	47	3	1	8
1712	47	0	2	8
1713	47	1	2	8
1714	47	2	2	8
1715	47	3	2	8
1716	47	0	3	8
1717	47	0	1	8
1718	47	1	1	8
1719	47	2	1	8
1720	47	3	1	8
1721	47	0	2	8
1722	47	1	2	8
1723	47	2	2	8
1724	47	3	2	8
1725	47	0	3	8
1726	47	0	1	8
1727	47	1	1	8
1728	47	2	1	8
1729	47	3	1	8
1730	47	0	2	8
1731	47	1	2	8
1732	47	2	2	8
1733	47	3	2	8
1734	47	0	3	8
1735	47	0	1	8
1736	47	1	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1737	47	2	1	8
1738	47	3	1	8
1739	47	0	2	8
1740	47	1	2	8
1741	47	2	2	8
1742	47	3	2	8
1743	47	0	3	8
1744	47	0	1	8
1745	47	1	1	8
1746	47	2	1	8
1747	47	3	1	8
1748	47	0	2	8
1749	47	1	2	8
1750	47	2	2	8
1751	47	3	2	8
1752	47	0	3	8
1753	47	0	1	8
1754	47	1	1	8
1755	47	2	1	8
1756	47	3	1	8
1757	47	0	2	8
1758	47	1	2	8
1759	47	2	2	8
1760	48	3	2	8
1761	48	0	3	8
1762	48	0	1	8
1763	48	1	1	8
1764	48	2	1	8
1765	48	3	1	8
1766	48	0	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1767	48	1	2	8
1768	48	2	2	8
1769	48	3	2	8
1770	48	0	3	8
1771	48	0	1	8
1772	48	1	1	8
1773	48	2	1	8
1774	48	3	1	8
1775	48	0	2	8
1776	48	1	2	8
1777	48	2	2	8
1778	48	3	2	8
1779	48	0	3	8
1780	48	0	1	8
1781	48	1	1	8
1782	48	2	1	8
1783	48	3	1	8
1784	48	0	2	8
1785	48	1	2	8
1786	48	2	2	8
1787	48	3	2	8
1788	48	0	3	8
1789	48	0	1	8
1790	48	1	1	8
1791	48	2	1	8
1792	48	3	1	8
1793	48	0	2	8
1794	48	1	2	8
1795	48	2	2	8
1796	48	3	2	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1797	48	0	3	8
1798	48	0	1	8
1799	48	1	1	8
1800	48	2	1	8
1801	48	3	1	8
1802	48	0	2	8
1803	48	1	2	8
1804	48	2	2	8
1805	48	3	2	8
1806	48	0	3	8
1807	48	0	1	8
1808	48	1	1	8
1809	48	2	1	8
1810	48	3	1	8
1811	48	0	2	8
1812	48	1	2	8
1813	48	2	2	8
1814	48	3	2	8
1815	48	0	3	8
1816	48	0	1	8
1817	48	1	1	8
1818	48	2	1	8
1819	48	3	1	8
1820	48	0	2	8
1821	48	1	2	8
1822	48	2	2	8
1823	48	3	2	8
1824	48	0	3	8
1825	48	0	1	8
1826	48	1	1	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1827	48	2	1	8
1828	48	3	1	8
1829	48	0	2	8
1830	48	1	2	8
1831	48	2	2	8
1832	49	3	2	8
1833	49	0	3	8
1834	49	0	1	8
1835	49	1	1	8
1836	49	2	1	8
1837	49	3	1	8
1838	49	0	2	8
1839	49	1	2	8
1840	49	2	2	8
1841	49	3	2	8
1842	49	0	3	8
1843	49	0	1	8
1844	49	1	1	8
1845	49	2	1	8
1846	49	3	1	8
1847	49	0	2	8
1848	49	1	2	8
1849	49	2	2	8
1850	49	3	2	8
1851	49	0	3	8
1852	49	1	3	8
1853	49	2	3	8
1854	49	3	3	8
1855	49	0	4	8
1856	49	1	4	8

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1857	49	0	1	8
1858	49	1	1	8
1859	49	2	1	8
1860	49	3	1	8
1861	49	0	2	8
1862	49	1	2	8
1863	49	2	2	8
1864	49	3	2	8
1865	49	0	3	8
1866	49	1	3	8
1867	49	2	3	8
1868	49	3	3	8
1869	49	0	4	8
1870	49	1	4	8
1871	49	0	1	8
1872	49	1	1	11
1873	49	2	1	11
1874	49	3	1	11
1875	49	0	2	11
1876	49	1	2	11
1877	49	2	2	11
1878	49	3	2	11
1879	49	0	3	11
1880	49	1	3	11
1881	49	2	3	11
1882	49	3	3	11
1883	49	0	4	11
1884	49	1	4	11
1885	49	0	1	11
1886	49	1	1	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1887	49	2	1	11
1888	49	3	1	11
1889	49	0	2	11
1890	49	1	2	11
1891	49	2	2	11
1892	49	3	2	11
1893	49	0	3	11
1894	49	1	3	11
1895	49	2	3	11
1896	49	3	3	11
1897	49	0	4	11
1898	49	1	4	11
1899	49	1	1	11
1900	49	2	1	11
1901	49	3	1	11
1902	49	0	2	11
1903	49	0	1	11
1904	49	1	1	11
1905	49	2	1	11
1906	49	3	1	11
1907	49	0	2	11
1908	50	0	1	11
1909	50	1	1	11
1910	50	2	1	11
1911	50	3	1	11
1912	50	0	2	11
1913	50	0	1	11
1914	50	1	1	11
1915	50	2	1	11
1916	50	3	1	11

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1917	50	0	2	11
1918	50	0	1	11
1919	50	0	1	11
1920	50	1	1	11
1921	50	2	1	11
1922	50	3	1	11
1923	50	0	2	11
1924	50	1	2	11
1925	50	2	2	11
1926	50	3	2	11
1927	50	0	3	11
1928	50	1	3	11
1929	50	2	3	11
1930	50	3	3	11
1931	50	0	4	11
1932	50	1	4	11
1933	50	2	4	11
1934	50	3	4	11
1935	50	0	5	11
1936	50	1	5	7
1937	50	3	2	7
1938	50	0	3	7
1939	50	1	3	7
1940	50	2	3	7
1941	50	0	1	7
1942	50	1	1	7
1943	50	2	1	7
1944	50	3	1	7
1945	50	0	2	7
1946	50	1	2	7

JMIC Number	Vehicle Wave Assignment	Assembly Station Number	Station Decision Equation Number	Type of Vehicle Served
1947	50	2	2	7
1948	50	3	2	7
1949	50	0	3	7
1950	50	1	3	7
1951	50	2	3	7
1952	50	0	1	7
1953	50	1	1	7
1954	50	2	1	7
1955	50	3	1	7
1956	50	0	2	7
1957	50	1	2	7
1958	50	2	2	7
1959	50	3	2	7
1960	50	0	3	7
1961	50	1	3	7
1962	50	2	3	7
1963	50	0	1	7
1964	50	1	1	7
1965	50	2	1	7
1966	50	3	1	7
1967	50	0	2	7
1968	51	1	2	7
1969	51	2	2	7
1970	51	3	2	7
1971	51	0	3	7
1972	51	1	3	7
1973	51	2	3	7
1974	51	3	1	7
1975	51	0	1	7
1976	51	1	1	32

## Vehicle Characteristics

Vehicle Index	Vehicle Type	Forward Speed (ft/hr)	Maneuvering Speed (ft/hr)	Number of JMICs Required	Fork Truck Required During Vehicle Loading? (T/F)
1	TANK	12240	4680	8	1
2	HMMWV CARGO	18720	16200	1	0
3	LAV	16560	13320	2	0
4	EFV	10800	3600	2	0
5	AAV	10080	3600	2	0
6	ACE	12240	4680	1	0
7	LVS	16200	3240	8	1
8	MTVR	14040	2880	8	1
9	MTVRXLWB	14040	2880	12	1
10	HMMWV TRAILER	18720	16200	2	0
11	MTVR TRAILER	14040	2880	4	1
12	LVS TRAILER	16200	3240	4	1
13	HMMWV OTHER	18720	16200	1	0
14	HMMWV	19800	7200	1	0
15	HMMWV	19800	7200	1	0
16	HMMWV	19800	7200	1	0
17	HMMWV	44550	16200	1	0
18	HOWITZER	19800	7200	1	0
19	RT FORKLIFT	19800	7200	1	0
20	RT TRACTOR	19800	7200	1	0
21	LAV	19800	7200	2	0
22	XLW B MTVR	19800	7200	1	0
23	BOAT BRIDGE	19800	7200	1	0
24	FORKLIFT	19800	7200	1	0
25	TRACTOR	19800	7200	1	0
26	ASSAULT BREACHER	19800	7200	1	0
27	TRACTOR	19800	7200	1	0

Vehicle Index	Vehicle Type	Forward Speed (ft/hr)	Maneuvering Speed (ft/hr)	Number of JMICs Required	Fork Truck Required During Vehicle Loading? (T/F)
28	BRIDGE	19800	7200	1	0
29	LVS TRAILER	19800	7200	1	0
30	HMMWV	19800	7200	2	0
31	MOTOR CYCLE	29700	10800	1	0
32	DITCHER	19800	7200	1	0

### Vehicle Assembly Wave Characteristics

Assembly Wave Number	Assembly Wave Length	Total Number of JMICs Required For Assembly Wave
1	8	36
2	12	17
3	5	10
4	5	10
5	5	10
6	7	14
7	13	18
8	11	15
9	14	32
10	15	30
11	15	39
12	11	69
13	14	47
14	12	60
15	14	31
16	18	18
17	17	17

Assembly Wave Number	Assembly Wave Length	Total Number of JMICs Required For Assembly Wave
18	16	16
19	23	40
20	6	36
21	5	34
22	5	10
23	8	58
24	9	72
25	16	58
26	11	68
27	10	36
28	8	64
29	10	55
30	16	16
31	18	18
32	22	35
33	10	68
34	9	72
35	18	80
36	11	23
37	7	84
38	8	8
39	8	4
40	9	9
41	11	28
42	17	17
43	18	18
44	23	43
45	9	72
46	9	72

Assembly Wave Number	Assembly Wave Length	Total Number of JMICs Required For Assembly Wave
47	9	72
48	9	72
49	14	76
50	18	60
51	4	9

## Notional MEB Equipment List

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
1	1	E1888	TANK, COMBAT, FT, 120MM GUN	1
2	1	E1888	TANK, COMBAT, FT, 120MM GUN	1
3	1	E1888	TANK, COMBAT, FT, 120MM GUN	1
4	1	E1888	TANK, COMBAT, FT, 120MM GUN	1
5	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	1
6	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	1
7	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	1
8	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	1
9	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
10	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
11	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
12	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
13	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
14	3	E0947	LIGHT ARMORED VEHICLE	2
15	3	E0947	LIGHT ARMORED VEHICLE	2
16	3	E0947	LIGHT ARMORED VEHICLE	2
17	3	E0947	LIGHT ARMORED VEHICLE	2
18	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	2
19	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	2
20	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	2
21	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	3
22	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	3
23	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	3
24	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	3
25	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	3
26	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	4

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
27	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	4
28	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	4
29	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	4
30	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	4
31	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	5
32	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	5
33	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	5
34	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	5
35	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	5
36	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	6
37	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	6
38	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	6
39	4	E0858	EXPEDITIONARY FIGHTINGVEHICLE (CMND)	6
40	3	E0948	LAV, LOGISTICS	6
41	3	E0942	LAV ANTI-TANK	6
42	3	E0942	LAV ANTI-TANK	6
43	3	E0949	LIGHT ARMORED VEHICLE MORTAR CARRIER	7
44	13	D1125	TRUCK, TOW CARRIER	7
45	13	D1125	TRUCK, TOW CARRIER	7
46	3	E0947	LIGHT ARMORED VEHICLE	7
47	3	E0947	LIGHT ARMORED VEHICLE	7
48	3	E0947	LIGHT ARMORED VEHICLE	7
49	3	E0947	LIGHT ARMORED VEHICLE	7
50	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	7
51	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	7
52	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	7
53	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	7
54	6	B0589	EXCAVATOR, COMBAT (ACE)	7
55	6	B0589	EXCAVATOR, COMBAT (ACE)	7
56	11	B1298	LINE CHARGE LAUNCH KIT, TRLR MTD	8
57	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	8

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
58	3	E0948	LAV, LOGISTICS	8
59	3	E0948	LAV, LOGISTICS	8
60	3	E0950	LAV MAINTENANCE/RECOVERY	8
61	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	8
62	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	8
63	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	8
64	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	8
65	11	B1298	LINE CHARGE LAUNCH KIT, TRLR MTD	8
66	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	8
67	1	E1888	TANK, COMBAT, FT, 120MM GUN	9
68	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	9
69	13	D1001	TRK AMB, 2 LITTER ARMD, 1 1/4 TON HMMWV	9
70	13	D1001	TRK AMB, 2 LITTER ARMD, 1 1/4 TON HMMWV	9
71	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
72	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	9
73	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
74	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	9
75	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
76	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	9
77	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
78	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
79	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	9
80	3	E0946	LAV COMMAND AND CONTROL (BN)	9
81	3	E0947	LIGHT ARMORED VEHICLE	10
82	3	E0948	LAV, LOGISTICS	10
83	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
84	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
85	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
86	5	E0856	ASSAULT AMPHIBIOUS VEHICLE, RECOVERY	10
87	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
88	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
89	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	10
90	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	10
91	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
92	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	10
93	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
94	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	10
95	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	10
96	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	11
97	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
98	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	11
99	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
100	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
101	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
102	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
103	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
104	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
105	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
106	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	11
107	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	11
108	8	D0198	HIMARS LAUNCHER	11
109	9	D1062	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	11
110	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	11
111	9	D1062	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	12
112	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	12
113	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	12
114	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	12
115	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	12
116	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	12
117	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	12
118	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	12
119	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	12

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
120	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	12
121	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	12
122	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	13
123	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	13
124	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	13
125	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	13
126	10	D0080	CHASSIS, TRLR, GENERAL PURPOSE, 3 1/2 TON, 2-WHL	13
127	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	13
128	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	13
129	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	13
130	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	13
131	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	13
132	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	13
133	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	13
134	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	13
135	6	B0589	EXCAVATOR, COMBAT (ACE)	13
136	6	B0589	EXCAVATOR, COMBAT (ACE)	14
137	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	14
138	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	14
139	2	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	14
140	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	14
141	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	14
142	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	14
143	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	14
144	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	14
145	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	14
146	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	14
147	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	14
148	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	15
149	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	15
150	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	15

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
151	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
152	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
153	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
154	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
155	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
156	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
157	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
158	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
159	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
160	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
161	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	15
162	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
163	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
164	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
165	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
166	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
167	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
168	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
169	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	16
170	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
171	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
172	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
173	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
174	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
175	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
176	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
177	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
178	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
179	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	16
180	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	17
181	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	17

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
182	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	17
183	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	17
184	13	D1125	TRUCK,UTILITY, TOW CARRIER, 1 1/4 TON W/EQUIP HMMWV	17
185	13	D1125	TRUCK, TOW CARRIER	17
186	13	D1125	TRUCK, TOW CARRIER	17
187	13	D1125	TRUCK, TOW CARRIER	17
188	14	AX001	MRC JTRS	17
189	14	AX001	MRC JTRS	17
190	14	AX001	MRC JTRS	17
191	14	AX001	MRC JTRS	17
192	14	AX001	MRC JTRS	17
193	14	AX001	MRC JTRS	17
194	14	AX001	MRC JTRS	17
195	14	AX001	MRC JTRS	17
196	14	AX001	MRC JTRS	17
197	14	AX001	MRC JTRS	18
198	14	AX001	MRC JTRS	18
199	14	AX001	MRC JTRS	18
200	14	AX001	MRC JTRS	18
201	14	AX001	MRC JTRS	18
202	14	AX001	MRC JTRS	18
203	14	AX001	MRC JTRS	18
204	14	AX001	MRC JTRS	18
205	14	AX001	MRC JTRS	18
206	14	AX001	MRC JTRS	18
207	14	AX001	MRC JTRS	18
208	14	AX001	MRC JTRS	18
209	14	AX001	MRC JTRS	18
210	14	AX001	MRC JTRS	18
211	15	DX101	HMMWV (MANPADS)	18
212	15	DX101	HMMWV (MANPADS)	18

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
213	15	DX101	HMMWV (MANPADS)	19
214	15	DX101	HMMWV (MANPADS)	19
215	15	DX101	HMMWV (MANPADS)	19
216	16	D0308	SHOP SET, CONTACT MAINTENANCE	19
217	16	D0308	SHOP SET, CONTACT MAINTENANCE	19
218	17	D1002	TRK AMB, 2 LITTER, SOFT TOP, 1 1/4 TON HMMWV	19
219	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
220	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
221	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
222	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
223	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
224	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
225	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
226	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
227	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
228	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
229	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
230	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
231	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
232	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
233	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
234	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
235	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	19
236	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	20
237	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	20
238	1	E1888	TANK, COMBAT, FT, 120MM GUN	20
239	1	E1888	TANK, COMBAT, FT, 120MM GUN	20
240	1	E1888	TANK, COMBAT, FT, 120MM GUN	20
241	1	E1888	TANK, COMBAT, FT, 120MM GUN	20
242	1	E1888	TANK, COMBAT, FT, 120MM GUN	21
243	1	E1888	TANK, COMBAT, FT, 120MM GUN	21

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
244	1	E1888	TANK, COMBAT, FT, 120MM GUN	21
245	1	E1888	TANK, COMBAT, FT, 120MM GUN	21
246	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	21
247	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	22
248	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	22
249	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	22
250	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	22
251	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	22
252	4	E0857	EXPEDITIONARY FIGHTING VEHICLE (PERS)	23
253	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
254	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
255	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
256	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
257	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
258	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
259	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	23
260	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
261	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
262	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
263	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
264	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
265	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
266	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
267	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
268	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	24
269	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
270	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
271	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
272	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
273	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
274	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
275	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	25
276	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
277	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
278	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
279	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
280	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
281	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
282	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	25
283	18	E0671	XM 777 LW155	25
284	18	E0671	XM 777 LW155	25
285	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	26
286	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	26
287	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	26
288	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	26
289	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X5	26
290	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	26
291	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X5	26
292	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	26
293	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X6	26
294	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	26
295	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X6	26
296	12	D08XX	Trl,r Mk xx Flat Rack (repl Mk14, Mk17, Mk18)	27
297	19	B2566	TRUCK,FORKLIFT ROUGH TERRAIN 4000 LB	27
298	19	B2566	TRUCK,FORKLIFT ROUGH TERRAIN 4000 LB	27
299	20	B2567	TRACTOR, RT, ARTICULATED STEER	27
300	21	A0966	MEWSS	27
301	21	A0966	MEWSS	27
302	21	A0966	MEWSS	27
303	8	D0198	HIMARS LAUNCHER	27
304	8	D0198	HIMARS LAUNCHER	27
305	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	27

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
306	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	28
307	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	28
308	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	28
309	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	28
310	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	28
311	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	28
312	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	28
313	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	28
314	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	29
315	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	29
316	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	29
317	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	29
318	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	29
319	9	E06X4	HIMARS RSV TRK,CARGO,7T XLWB (MTVR)	29
320	11	E06X5	HIMARS RST (MTVR TRAILER VARIANT)	29
321	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	29
322	13	D1159	TRK, UTILITY, ARMT CARR W/SA 1 1/4 TON W/EQUIP HMM	29
323	14	AX001	MRC JTRS	29
324	14	AX001	MRC JTRS	30
325	14	AX001	MRC JTRS	30
326	14	AX001	MRC JTRS	30
327	14	AX001	MRC JTRS	30
328	14	AX001	MRC JTRS	30
329	14	AX001	MRC JTRS	30
330	14	AX001	MRC JTRS	30
331	14	AX001	MRC JTRS	30
332	14	AX001	MRC JTRS	30
333	14	AX001	MRC JTRS	30
334	14	AX001	MRC JTRS	30
335	14	AX001	MRC JTRS	30
336	14	AX001	MRC JTRS	30

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
337	14	AX001	MRC JTRS	30
338	14	AX001	MRC JTRS	30
339	14	AX001	MRC JTRS	30
340	17	D1002	TRK AMB, 2 LITTER, SOFT TOP, 1 1/4 TON HMMWV	31
341	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
342	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
343	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
344	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
345	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
346	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
347	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
348	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
349	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
350	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
351	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
352	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
353	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
354	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
355	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
356	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
357	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	31
358	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
359	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
360	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
361	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
362	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
363	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
364	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
365	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
366	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	32
367	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
368	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
369	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
370	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
371	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
372	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
373	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
374	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
375	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
376	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	32
377	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	32
378	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	32
379	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	32
380	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	33
381	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	33
382	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
383	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
384	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
385	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
386	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
387	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
388	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
389	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	33
390	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
391	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
392	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
393	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
394	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
395	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
396	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
397	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34
398	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	34

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
399	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	35
400	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	35
401	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
402	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
403	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
404	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
405	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
406	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
407	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
408	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
409	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
410	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
411	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
412	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
413	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
414	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
415	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
416	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	35
417	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	36
418	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	36
419	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	36
420	11	D0880	TRLR, TANK, WATER, 400 GAL, 1 1/2T, 2-WHL	36
421	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
422	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
423	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
424	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
425	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
426	8	D1073	TRUCK, DUMP, 7T (MTVR)W/WINCH	36
427	22	D1213	MEDIUM TACTICAL VEHICLE REPLACEMENT, WRECKER	36
428	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
429	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
430	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
431	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
432	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
433	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
434	9	D1062	TRK,CARGO,7T XLWB (MTVR)	37
435	18	E0671	XM 777 LW155	38
436	18	E0671	XM 777 LW155	38
437	18	E0671	XM 777 LW155	38
438	18	E0671	XM 777 LW155	38
439	23	B0114	BOAT, BRIDGE ERECTION	38
440	23	B0114	BOAT, BRIDGE ERECTION	38
441	23	B0114	BOAT, BRIDGE ERECTION	38
442	23	B0114	BOAT, BRIDGE ERECTION	38
443	23	B0114	BOAT, BRIDGE ERECTION	39
444	23	B0114	BOAT, BRIDGE ERECTION	39
445	24	B2561	TRK, FORKLIFT	39
446	24	B2561	TRK, FORKLIFT	39
447	24	B2561	TRK, FORKLIFT	39
448	24	B2561	TRK, FORKLIFT	39
449	20	B2567	TRACTOR, RT, ARTICULATED STEER	39
450	20	B2567	TRACTOR, RT, ARTICULATED STEER	39
451	20	B2567	TRACTOR, RT, ARTICULATED STEER	40
452	20	B2567	TRACTOR, RT, ARTICULATED STEER	40
453	20	B2567	TRACTOR, RT, ARTICULATED STEER	40
454	25	B2460	TRACTOR, FT, W/ANGLE BLADE	40
455	25	B2460	TRACTOR, FT, W/ANGLE BLADE	40
456	26	B0ABV	ASSAULT BREACHER VEHICLE (ABV) W/MINE PLOW ATTACHED	40
457	6	B0589	EXCAVATOR, COMBAT (ACE)	40
458	27	B2482	TRACTOR, ALL WHEEL DRIVE W/ATTACHMENTS	40
459	27	B2482	TRACTOR, ALL WHEEL DRIVE W/ATTACHMENTS	40
460	28	E0149	BRIDGE, SCISSOR FOR AVL B	41

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
461	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	41
462	29	D0881	TRLR, RIBBON BRIDGE	41
463	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	41
464	29	D0881	TRLR, RIBBON BRIDGE	41
465	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	41
466	29	D0881	TRLR, RIBBON BRIDGE	41
467	14	AX001	MRC JTRS	41
468	14	AX001	MRC JTRS	41
469	14	AX001	MRC JTRS	41
470	14	AX001	MRC JTRS	41
471	14	AX001	MRC JTRS	42
472	14	AX001	MRC JTRS	42
473	14	AX001	MRC JTRS	42
474	14	AX001	MRC JTRS	42
475	14	AX001	MRC JTRS	42
476	14	AX001	MRC JTRS	42
477	14	AX001	MRC JTRS	42
478	14	AX001	MRC JTRS	42
479	14	AX001	MRC JTRS	42
480	14	AX001	MRC JTRS	42
481	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
482	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
483	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
484	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
485	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
486	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
487	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	42
488	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
489	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
490	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
491	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
492	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
493	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
494	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
495	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
496	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
497	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
498	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
499	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
500	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
501	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
502	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
503	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
504	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
505	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	43
506	2	D1158	TRK, UTILITY, CARGO TRP CARR 1 1/4 TON W/EQUIP, HM	44
507	30	A3232	TRANSPORTABLE TACSATCOM (SMART-T) AN/TSC154	44
508	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	44
509	10	D0085	CHASSIS, TRAILER, 3/4 T 2 WHEEL	44
510	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
511	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
512	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
513	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
514	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
515	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
516	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
517	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
518	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
519	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
520	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
521	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
522	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
523	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
524	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
525	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
526	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
527	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
528	10	D0850	TRLR, CARGO, 3/4T, 2-WHL	44
529	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
530	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
531	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
532	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
533	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
534	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
535	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
536	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
537	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	45
538	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
539	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
540	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
541	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
542	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
543	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
544	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
545	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
546	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	46
547	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
548	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
549	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
550	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
551	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
552	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
553	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
554	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
555	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	47
556	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
557	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
558	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
559	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
560	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
561	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
562	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
563	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
564	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	48
565	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	49
566	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	49
567	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	49
568	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	49
569	8	D0198	MEDIUM TACTICAL VEHICLE REPLACEMENT	49
570	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
571	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
572	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
573	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
574	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
575	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
576	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
577	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
578	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	49
579	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
580	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
581	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
582	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
583	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
584	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50

Vehicle Priority	Vehicle Type Index	TAMCN	Equipment Nomenclature	Wave Assignment
585	11	D0860	TRAILER, CARGO, 1-1/2T, 2-WHL,	50
586	31	D0201	MOTORCYCLE, MILITARY, 2-WHL	50
587	31	D0201	MOTORCYCLE, MILITARY, 2-WHL	50
588	31	D0201	MOTORCYCLE, MILITARY, 2-WHL	50
589	31	D0201	MOTORCYCLE, MILITARY, 2-WHL	50
590	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	50
591	29	D0881	TRLR, RIBBON BRIDGE	50
592	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X4	50
593	29	D0881	TRLR, RIBBON BRIDGE	50
594	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X5	50
595	29	D0881	TRLR, RIBBON BRIDGE	50
596	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X5	50
597	29	D0881	TRLR, RIBBON BRIDGE	51
598	7	D0209	POWER UNIT, FRONT, 12 1/2 TON, 4X6	51
599	29	D0881	TRLR, RIBBON BRIDGE	51
600	32	B0355	COMPACT/DITCHER	51

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## **APPENDIX C – STAKEHOLDER QUESTIONNAIRE**

- 1) What value do you see the sea base to you?
- 2) Is there a capability gap with current military cargo platforms that would limit transportability from a sea base to the insertion point? Please describe in detail
- 3) For each operational scenario below what is the OPTEMPO for the ASE (please complete questions below with regard to each scenario)
  - a. CONUS to sea base
  - b. sea base to debarkation point (combat)
  - c. sea base to debarkation point (humanitarian)
  - d. Cargo on-load & off-load
    - i. How fast does it need to be moved?
    - ii. How far will it have to be moved?
    - iii. What are the environmental conditions?
  - iv. Will the ASE require refueling while undergoing this mission?
  - v. What are the obstacles (man made or natural) that the vessel may encounter
  - vi. Will the ASE require defensive measures? (countermeasures, machine gun, signature reduction)
- 4) Under what sea states will cargo transfer take place?
  - a. What are the primary mission items that need to be moved?
  - b. What are the typical weather conditions one may have to operate in with regards to transit and cargo operations?

- c. What is the daily required thru-put rate in terms of cargo type, tonnage, area, volume and deck point loads?
- d. How will the cargo be loaded and secured in the vessel
- e. Will bulk, liquid, containerized cargo, personnel or a combination thereof be transported
- f. Will rolling stock be loaded
- g. How many trips per day are envisioned for one ASE

5) What other vehicles will the ASE be required to interface with (consider ships, aircraft, and other various operational military ground vehicles – be specific)

- a. Military
- b. Commercial
- c. Coalition / NATO

6) Based on previous military operations what is the one operational characteristic could make the ASE indispensable

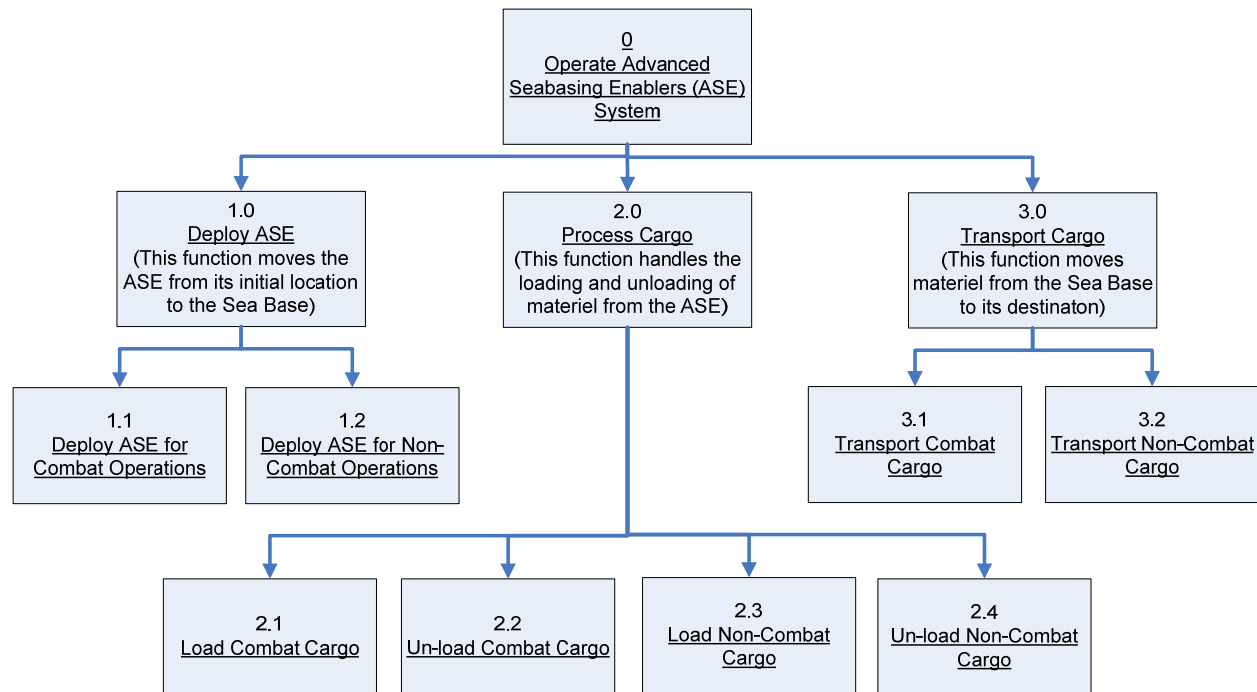
7) Where do you believe the cargo has to be delivered?

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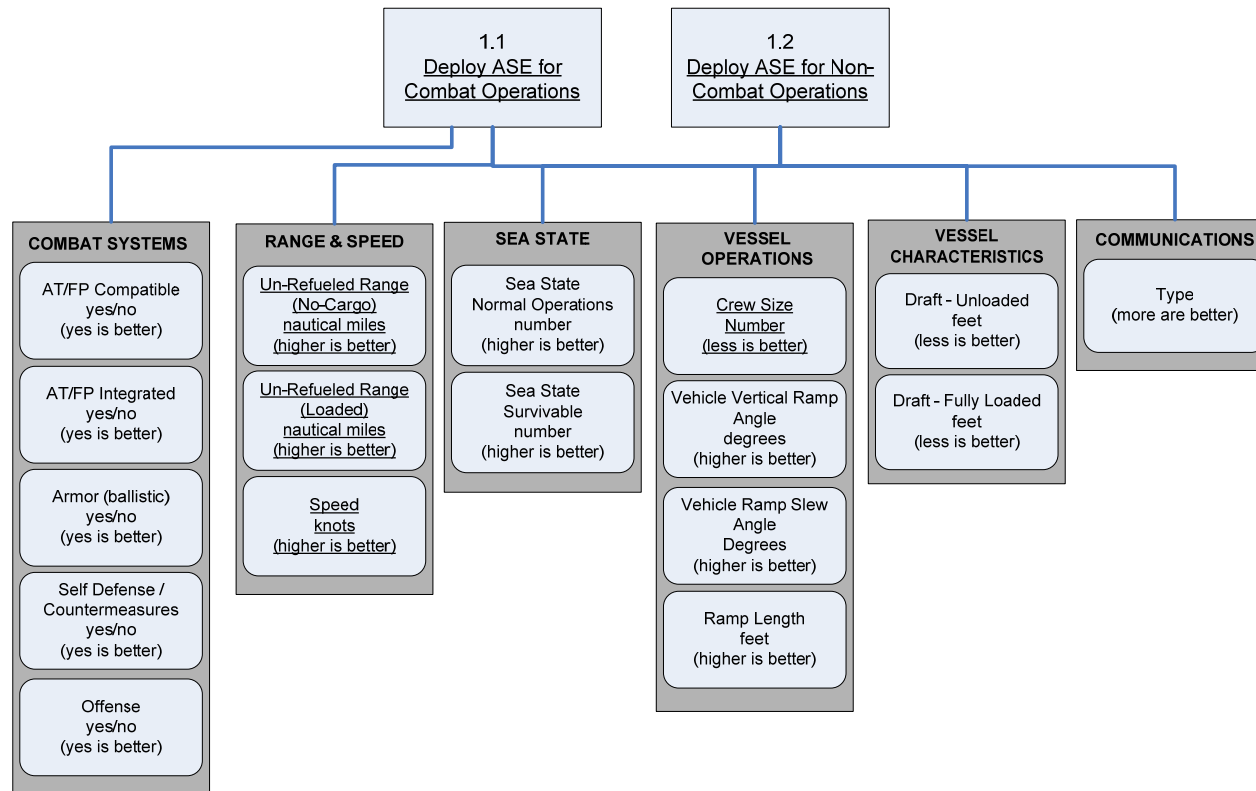
## **APPENDIX D – VALUE SYSTEMS OBJECTIVES HIERACHY**

### REVISED PROBLEM STATEMENT

*For a sea base to be truly beneficial a capability must exist that supports efficiently transporting needed materiel from the sea base to the desired debarkation point. The capability must support peace-time, non-combat operations' and war-time, combat operations' logistics and support needs. The solution must be cost effective and capable of operating under all environmental conditions, including sea states, under which necessary military operations are expected to take place and must support a transport rate sufficient to ensure materiel is delivered within operational time requirements.*



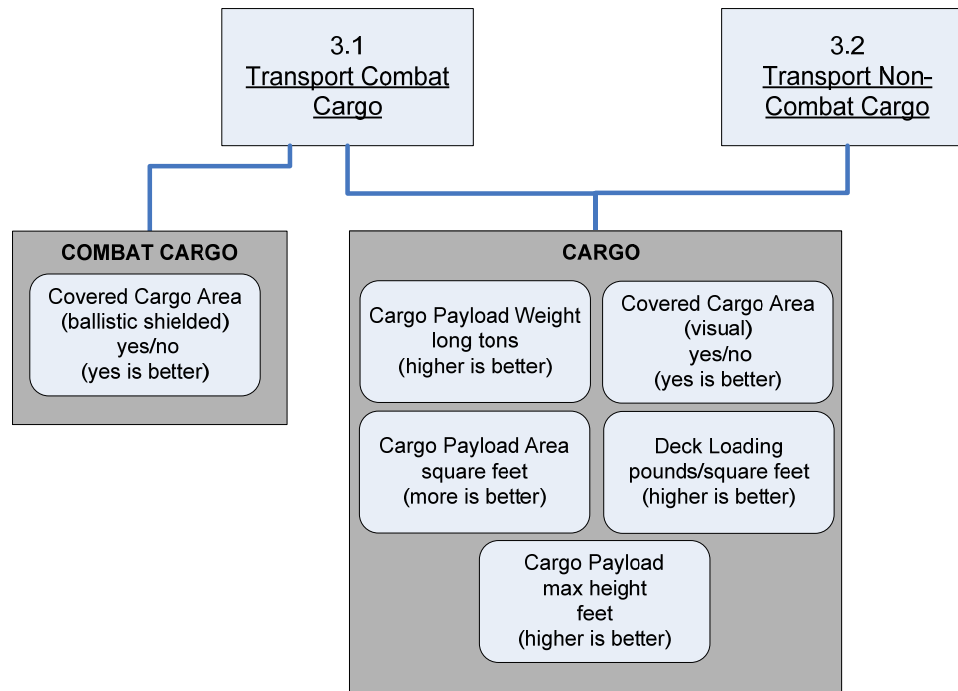
### **Top Level Functions**



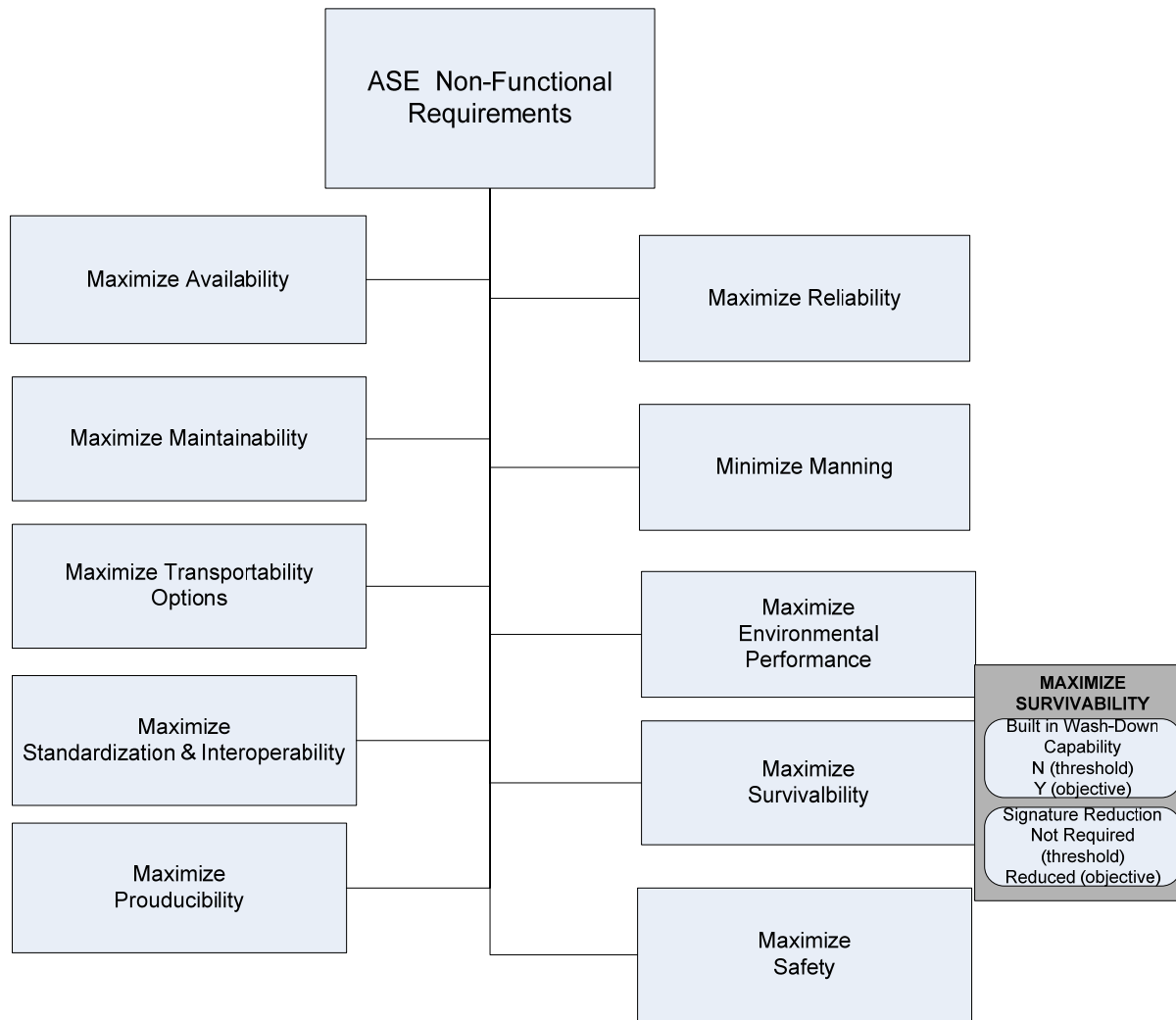
**Objectives Hierarchy – Deploy ASE**



2.1 <u>Load Combat Cargo</u>	2.2 <u>Un-load Combat Cargo</u>	2.1 <u>Load Combat Cargo</u>	2.2 <u>Un-load Combat Cargo</u>
<b>CARGO</b>			
	Cargo Payload Weight long tons (higher is better)	Cargo Transfer Capability Crane Ops yes/no (yes is better)	
	Cargo Payload Area square feet (more is better)	Cargo Transfer Capability RO/RO yes/no (yes is better)	
	Cargo Payload max height feet (higher is better)	Cargo Transfer Capability Vertical Lift yes/no (yes is better)	
	Deck Loading pounds/square feet (higher is better)	Covered Cargo Area (visual) yes/no (yes is better)	
		Covered Cargo Area (ballistic shielded) yes/no (yes is better)	
<b>SEA STATE</b>			
	Sea State Seabased Cargo Operations number (higher is better)		



**Objectives Hierarchy – Load/Un-load and Transfer Cargo**



### Non-Functional Requirements

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